UNEVEN DEVELOPMENT AND PERIPHERAL CAPITALISM:

THE CASE OF BRAZILIAN INFORMATICS

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ABBREVIATIONS

ABICOMP	Associacao da Industria Brasileira de Computadores e Perifericos
ABINEE	Associacao Brasileira da Industria Eletro-eletronica
AIC	Advanced Industrialized Country
ASSESPRO	Associacao das Empresas de Servicos de Informatica
BIOTEC	Polo de Biotecnologia do Rio de Janeiro
BNDES	Banco Nacional de Desenvolvimento Economico e Social
CAD	Computer Aided Design
CAPES	Cordenacao de Aperfeicoamento de Profissionais do Ensino Superior
CAPRE	Comissao de Atividades de Processamento Eletronico
CDI	Conselho de Desenvolvimento Industrial
CERTI	Centro Regional de Tecnologia e Informatica
CIATEC	Compania de Desenvolvimento do Polo de Alta Tecnologia de Campinas
CITPAR	Centro de Integracao de Tecnologia do Para
CNPq	Conselho Nacional de Desenvolvimento Cientifico
COBRA	Computadores Brasileiros SA
CONIN	Conselho Nacional de Informatica
CPqD	Centro de Pesquisa e Desenvolvimento (Telebras)
CPU	Central Processing Unit
CTI	Centro Tecnico para a Informatica (SEI)
DARPA	Defense Advanced Research Projects Agency (USA)
DoD	Department of Defense (USA)
DTI	Department of TRade and Industry (UK)
EEC	European Economic Commission
EPI	Export Promotion Industrialization
FDI	Foreign Direct Investment
FINEP	Financiadora de Estudos e Projectos
FNDCT	Fundo Nacional de Desenvolvimento Scientifico e Tecnologico
FUCAPI	Fundacao Centro de Analises de Producao Industrial
GEICOM	Grupo Interministerial de Componentes e Materiais
GNP	Gross National Product
IBGE	Instituto Brasileiro de Geografia e Estatistica
IBM	International Business Machines
IC	Integrated Circuit
ICBM	Intercontinental Ballistic Missile
IDL	International Division of Labour
INPE	Instituto Nacional de Pesquisas Espaciais
IPO	International Procurement Office
ISI	Import Substitution Industrialization
ITA	Instituto Tecnico da Aeronautica
JECC	Japanese Electronic Computer Company (Japan)
LDCs	Less Developed Countries

ABBREVIATIONS cont.

MCT	Ministerio da Ciencia e Tecnologia
MIC	Ministerio de Industria e Comercio
MINICOM	Ministerio das Comunicacoes
MITI	Ministry of International Trade and Industry (Japan)
MPT	Ministry of Post and Telecommunications (UK)
NIC	Newly Industrialized Country
NIDL	New International Division of Labour
NIT	Nucleo de Inovacao Tecnologica, RJ
NPCT	Nucleo de Pesquisa em Ciencia e Tecnologia, Campinas
NTT	Nippon Telephone and Telegraph (Japan)
NUTEC	Fundacao Nucleo de Tecnologia Industrial, Fortaleza, CE
OEM	Original Equipment Manufacturer
PLANIN	Plano Nacional da Informatica
PNI	Politica Nacional de Informatica
PUC	Pontificia Universidade Catolica
RAM	Ready Access Memory
R&D	Research & Development
RIOTEC	Polo de Alta Tecnologia do Rio de Janeiro
SCP	Strategic Computing Programme
SDI	Strategic Defense Initiative
SEI	Secretaria Especial da Informatica
S&T	Science and Technology
SUCESU	Sociedade dos Usuarios de Computadores e Equipamentos Subsidiarios
SUDAM	Superintendencia de Desenvolvimento da Amazonia
SUDENE	Superintendencia de Desenvolvimento do Nordeste
SUFRAMA	Superintendencia da Zona Franca de Manaus
TNC	Transnational Corporation
UFMG	Universidade Federal de Minas Geraes
UFRGS	Universidade Federal do Rio Grande do Sul
UFRJ	Universidade Federal do Rio de Janeiro
UNCTC	United Nations Centre for Transnational Corporations
UNICAMP	Universidade Estadual de Campinas
UNCTAD	United Nations Commission for Trade & Development
USP	Universidade de Sao Paulo
VHSIC	Very High Speed Integrated Circuit Programme
ZFM	Zona Franca de Manaus
ZPE	Zonas Para Exportacao

ABSTRACT

This thesis examines the development of the Brazilian informatics industry and its relationship with and role in the international division of labour for informatics. The principal focus of the analysis is the Brazilian national policy for informatics (PNI). The PNI successes and failures at the national and regional level are related to the weak articulations between the Brazilian and the global informatics industry. The evidence for these fragile links are in the regional distribution patterns of the informatics industry throughout the national territory.

The thesis differs from previous studies of Brazilian development policies in its assertion that industry and firms have specific sets of social relations which are spatially grounded and these depend on technology, itself socially created. Previous studies however have depended solely upon technological criteria with which to evaluate Brazilian development strategies.

Five main points are covered: the organization of the global informatics industry; different forms of state intervention to cope with and secure nations' strategic stakes in this important industry in the AICs and NICs; interactions between this sector and other sectors of the national industry; and regional patterns of this sector's industrial development in the country. The thesis identifies contradictions between Brazilian policies for modernization of the economy as a whole and modernization of the informatics sector. Modernization requires introduction of new technologies (products and processes) which the heavily protected national informatics industry is not yet capable of producing. Current industrial (and therefore also regional) development bottlenecks faced by the Brazilian industry reflects structural rigidities in the nation's social-political structure. The inward-looking character of Brazil's informatics development policies, which are both unique (in national terms) and ambitious (in technological terms), the thesis argues, fails to take into account the global organization, and thus the role of international capital, in the informatics industry.

The thesis emphasizes that it was the need to solve economic problems that triggered the Brazilian development process. However, the development of informatics industries around the globe cannot be seen as a direct and exclusive cause of capital migration. Brazil, together, with other developing countries, is an integral part of the world system and must take this system into account in order to make the most of its possibilities.

INTRODUCTION

I.1 Aims and Issues

> "The National Informatics Policy has already survived the first phase of its implementation. Today the policy is confronted with new challenges to define new strategies and to set new priorities. This task becomes even more significant when Brazil needs to overcome the present economic crisis and to re-define its role in a more complex and interdependent world economy." (SEI, 1989a)

Until the late 1970s Brazil's electronics industry was controlled by foreign companies which operated in the country as final assemblers of products and as sellers of imported finished equipment.

Between 1979 and 1986 the production of informatics goods and services grew at an average of 30% a year. The industry's total profits added up to US$ 3.2 billion in 1987 (57% of which was realized by Brazilian firms). The value of computer installations was worth US$5.4 billion and 40% of the installed equipment was 'made in Brazil'. This activity was carried out by over 300 firms, 37 of which were Brazilian based subsidiaries of transnational corporations (hereafter TNCs), employing 150,000 people in an industry that was unevenly located across the national territory from Amazonia to Rio Grande do Sul. All of this has been supported through Brazil's national informatics policy (hereafter PNI) both with financial subsidies and institutional backing. This policy is stated in Law 7232 of 29 October 1984. The main objective of the 1984 Law of Informatics is to develop an informatics industry which would contribute to the social, cultural, political, technological and economic development of Brazilian society (Brazil: National Congress, 1984).

These events in Brazil follow a pattern of industrial growth of informatics sectors in others parts of the world. They are intimately linked to the development of electronics complexes first in the United States (1940s), then in Europe (1970s), and Japan (1970s), and more recently in many parts of the developing world (1980s). The aim of this thesis is to examine the links between developments in the informatics industry in Brazil and those which have taken place abroad, and the constraints to and possibilities for Brazil's informatics industry to achieve the goals outlined in the second national informatics plan (SEI, 1989a). It is argued here that the policies adopted by the Brazilian government for the past 15 to 20 years, albeit instrumental in the development

of the present industry, do not take into account the links between the development of the Brazilian industry and the development of informatics industries worldwide, and that no matter how relevant these policies might have been for Brazil, the national industry is part of a global industry and it is directly affected by events taking place globally.

The focus of the study is the informatics industry which includes producers of mini and microcomputer systems, and which has been at the centre of recent growth. By way of contrast, and considering the technological links between different sub-sectors, I compare the policies and performance of informatics with other sub-sectors of the electronics complex.

To develop this argument I examine the Brazilian experience in the context of the development of informatics industries in other parts of the world, particularly in the United States, Europe and Japan, and the experiences of other developing countries. The global changes in the informatics industry directly affect the evolution of this industry in a developing country like Brazil. The development of both Brazilian and international industries is situated within the context of capitalism. The uneven nature of capitalist development, evident in the asymmetrical configuration of the informatics industry worldwide is emphasized when examining the industry on a global scale. Lastly, in this thesis the industry is examined from a spatial regional perspective. This approach adds a new dynamic to the analysis of a fast changing industry. This regional perspective is particularly necessary given the almost complete neglect of this subject in the available literature.

To date, the literature has taken different foci and has used different criteria to measure the development of the Brazilian informatics industry. To some extent there have been attempts to pronounce on the successes and failures of the Informatics Law and subsequent national informatics plans. The government itself produces an annual survey on the industry and has published works on a variety of other related topics [1]. These data are widely used in the literature, which tends to focus on the political [2], economic [3] and technological [4] facets of the industry and policy. There is also a

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[1] See SEI 1982, 1984, 1985, 1986, 1987, 1988, 1989.

[2] Adler, 1986; Dantas, V. 1988; Tapia, 1984.

[3] Frischtak, 1986; Piragibe, 1985; Tigre, 1983.

[4] Piragibe, 1984; Tigre & Perine, 1984.

literature which compares the Brazilian experience with other countries' [1].

The opinions expressed on the Brazilian industrial development strategy are mixed. Some observers support Brazil's protectionist strategy, both as a prerequisite for and as a successful step towards the development of infant industries such as informatics [2]. Supporters of this strategy emphasize the development of nationalistic forces inside the government [3] and the economic, technological and employment implications of more autonomous industrial developments [4]. Others criticize the economic and technological bottlenecks of excessive protectionism. Or as one observer argues, despite protection the production of informatics goods in Brazil is still restricted to local markets and the production of standard and overly priced products (Frischtak, 1986:1). Similarly, another commentator links the slow pace of technological development, the persistence of wide technological gaps and the production of highly priced and standard equipment to a resistance to open up domestic markets to foreign trade and engage in greater bilateral ventures with leading TNCs (Cline, 1987).

Independent of the opinions given, studies focus on the uniqueness of the Brazilian initiative at the expense of, and often dissociated from, industrial and economic processes occurring at a global level. These studies fail to give equal importance to the social, political, economic and technological aspects of industrial development.

It is not very difficult to identify the relationship between the Brazilian and the international informatics industry. Piragibe described the Brazilian informatics policy as one that began internationalized, but that later had to be dismantled and controlled at a national level (Piragibe, 1985). Another observer identified the Brazilian informatics industry as international on the basis that it was dependent on international producers of main frame computers (Cline, 1987). Brazilian firms still rely heavily on the large international producers following the same technological trajectories and standards as they do, and the national industry is also heavily dependent on key imports of electronic components (microchips).

Brazil's informatics industry is distributed unevenly throughout the country and

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[1] Cline, 1987; Piragibe, 1986; Rushing & Brown, 1986.

[2] Adler, 1987; Dantas, 1987; Evans, 1979.

[3] Adler, 1986.

[4] Hewitt, 1988

the process of this unequal regional development is reflected in qualitative and quantitative variations in employment, R&D activities and production. Front-end functions (e.g. R&D and marketing) are primarily concentrated in the South East, while manufacturing activities are more widely spread. The roots of this regional pattern lie in the concentration of early electrical industries in and around S. Paulo and along the S. Paulo and Rio axis. This localization became self-perpetuating from the 1950s onward since other industries such as electronics, defense, automobiles, light and heavy manufacturing -all major users of informatics goods- have long concentrated in the South-East. From the late 1970s, other regions of the country began to emerge as sites for electronics firms. This industrial dispersal is partly the result of a range of regional development policy incentives designed to attract investment to different regions of the country. Competing regional development policies, initiated as early as the 1960s, have altered the spatial divisions of labour in Brazil. These initiatives include the creation of the Manaus Import Zone in the North, the proposal of export processing zones in the North-East and, most recently, the creation of science parks nationwide.

Others aspects of the development of industries like informatics are important to the discussion proposed here. The informatics industry is considered strategically important by both the developed and less developed nations. Technological aspects of informatics are constantly presenting these countries with new challenges. The new computing and telecommunications technologies have given rise to rapid and major changes in economic and organizational activities. New products create new markets, shift economic power among nations, lead to new services, dictate or allow new organizational schemes and re-define social relations. Technological developments in electronics have contributed to changing patterns of industrial agglomeration and dispersal worldwide.

The dynamism and continued spatial change that has characterized the informatics industry worldwide is not however simply a result of technological change. Other factors have contributed to this. First, the informatics industry is enmeshed in a global economic system, and as such it is affected by fluctuations in this global economy. Second, the strategic importance of informatics industries necessitates close participation by governments in the process of transnational expansion. Governments mediate technological and industrial development through the application of different policies. Most developed and developing countries, including Brazil, have implemented

some form of user and production related policies. Third, the international division of labour of the informatics industry has undergone significant changes during the 40 years of the industry. These changes are the result of national strategies adopted by different countries to compete with each other. Given the economic and technological supremacy of industries located in the Advanced Industrialized Countries (hereafter AICs), Newly Industrialized Countries (hereafter NICs) wishing to enter this industry are under severe pressure to form their national strategies in line with competing international trends.

Capital internationalization in the informatics industry is not an homogeneous process. The patterns of capital internationalization in the informatics industry have changed according to different stages of technological development both in the semiconductor and computer industries. Patterns of capital internationalization are associated with particular types of industrial relocation and expansion throughout the world, and the relocation and expansion of industrial capital in the informatics industry has had varied impact on the localities where these activities take place. The location of informatics firms in selected places can be both positive (contributing to the overall development of an area through the creation of jobs, raising taxes, etc.) and negative (contributing to environmental damage, overcrowding, deskilling, unemployment, employment shifts). For these reasons the successes and failures in the Brazilian informatics industry must be examined in an international context.

The arguments raised in this thesis touch on a number of questions about development including the nature and relevance of industrial development in countries like Brazil, the role of international capital and the patterns of capital internationalization in the developing world. The theoretical focus of this thesis is uneven development, and most specifically how this unevenness manifests itself over space. This is at times a problem, since many social scientists take space as a given variable, a by-product of development (see Massey, 1984:51; Duncan, 1989).

Much of the theoretical work on development and capital internationalization fails to consider space as a significant variable for industrial and social development (Smith, 1984). In this thesis I review dependency theory arguments, theories of capital internationalization, uneven development and regulation theory. The first theory does not see sustained development in the Third World as a possibility. The second theory focuses on the expansion and retraction of economic activities throughout the world. The third theory looks at the rise and fall of capitalism in a given locality as a response to

the cycles of growth and decline characteristic of capitalism. The last theory focuses on the role of the state as key actor in the development process over the last three or four decades.

The choice of Brazil as a case study is based on the following factors. First, Brazil allows for the examination of uneven development within a NIC. To a large extent, economic development in Brazil has not been paralleled by essential social developments. The discrepancies between economic growth and social inequality (including, but not only, uneven income distribution) in Brazil confirm and provide a context to examine the uneven nature of development within the country. Second, the state has had a clear role in Brazilian industrialization and overall development. Third, the position of Brazil in an international economic and political context has changed over the years. In short, Brazil offers an excellent case study of the role of the informatics industry in the development process.

I.2 Structure of the Thesis

This chapter outlines the main issues addressed in this thesis and discusses the technological and strategic aspects of the development of informatics worldwide. The first chapter develops the theoretical framework of this thesis. This framework examines competing development theories and how each interprets and explains development. A review of dependency theory (section 1.2) is followed by an evaluation of the usefulness of the theory of capital internationalization (NIDL) (section 1.3) to understanding industrial development in the last 20 years. Section 1.4 stresses the importance of historical and geographical uniqueness of economic development from the 1960s to the present in analyzing the development of the Brazilian and international informatics industries and the role of the state in these processes. Section 1.5 defines uneven development. The main points of the chapter are summarized in section 1.6.

The next six chapters (Chapter 2-7) move to an empirical examination of the informatics industry. For the sake of clarity and organization, it proceeds from the global level (Chapter 2) to the regional (Chapter 3) to the local level (Chapters 4 -7). It is important to emphasize, nevertheless, that each level is not a single entity but part of the totality (Morgan and Sayer, 1988)

The second chapter is contextual. It examines the internationalization of capital in informatics industries located in Europe, Japan and the United States and three

competing models of economic growth pursued by each of these countries/regions in the past 40 years. It also looks at the relationship between technological change and labour (section 2.3), technological change and capital internationalization (section 2.4) and the relationship between industry and regional development policies (section 2.5).

Chapter three provides information about the development of informatics industries in the developing world. Set in the context of global development, it discusses the position of the NICs in the international division of labour for informatics (section 3.2), and the types of government strategies that have been used to promote industrial development (section 3.3). Following the format used in Chapter two, the level of analysis then shifts to examine internationalization and technology transfer (section 3.4), employment changes (section 3.5), and industry and regional development (section 3.6).

Four chapters (four through seven) focus on the Brazilian informatics industry. Chapter four focuses on the national level, and using both secondary and primary sources of data it examines the evolution of the national informatics policy and its main components within a historical and economic context of the Brazilian industrialization (section 4.2). Section 4.3 compares and contrasts government support given to informatics and to other sectors of the electronics complex. Section 4.4 reviews the government support given to science and technology in Brazil.

Chapter five looks at economic performance of the informatics sector and the level of competitiveness of the Brazilian industry examining key criteria (sales, employment, and computer installations). Particular attention is paid to the case of electronic banking, since achievements in this sector have been used to illustrate that the industry as a whole is successful. Lastly, the position of Brazilian firms in the industry's international division of labour is examined (section 5.4).

Chapter six focuses on the geographical location of the Brazilian industry in terms of regional initiatives to promote its development, and historical patterns of industrial concentration in Brazil (section 6.2). Section 6.3 looks at the distribution of informatics and other electronics firms, of industrial users (section 6.4), and of regional sales and employment (section 6.5).

Chapter seven focuses on the six geographical regions where informatics and other electronics firms are located throughout the country. Linkages between these firms and the regions where they are located are examined.

The last chapter, eight, summarizes the main empirical findings of the thesis,

highlighting the contributions of this work in reviewing the Brazilian experience through an international lens and in identifying economic/industrial unevenness. It comments on the achievements and limitations of this work, and makes suggestions for future research on related topics. Finally, it re-examines the theoretical starting point in the light of this work. The research methodology and research documentation are discussed in the four appendixes.

The following section describes technological characteristics of the informatics industry. This discussion is set at a general rather than at a technical level and has two purposes: to show how information technology has been transferred from the AICs to the rest of the world, and to link technical aspects of the development of informatics technologies to social, political and economic developments.

I.3 Some Definitions: High technology, Electronics, Informatics

The electronics industry occupies a dominant position in so called high technologies. The activity includes three major groups of industries: Group 1: electronic components; Group 2: consumer electronics; and Group 3: industrial and professional electronics. Group 1 includes both electronic components such as semiconductors and integrated circuits. Group 2, consumer electronics, covers the entire range of audio-visual equipment, Finally, Group 3 includes instrumentation, computers and peripherals, telecommunications and industrial automation (UNCTC, 1983). Together they form what has been referred to as an electronics complex of industrial sectors, which are technically connected through digital technologies (Erber, 1985).

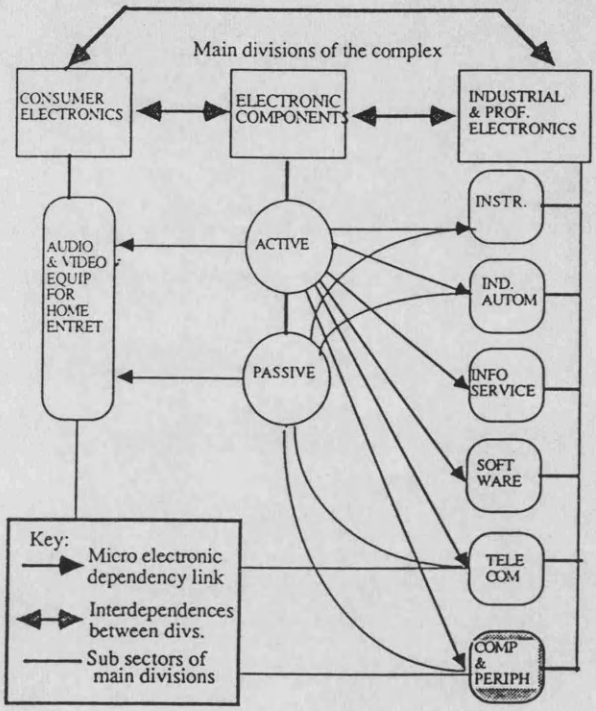
Wide and growing application of electronics in society have made this industry strategically important and economically strong. The digital technology used in computers allow the storage, production, analysis and circulation of information. A growing number of private and public users rely on information systems to organize and control data sets in the belief that an accurate and efficient control of records aids decision-making, facilitates the efficient flow of information between and within firms and countries and therefore determines their competitive position in the world.

Informatics is here defined as the ensemble of objects and techniques necessary for the electronic manipulation, processing and diffusion of information (data) where the computer is but a part of the whole system. The informatics industry is a productive sub-sector of Group 3 above, comprising the production of computers and the

supporting components needed for their functioning. The interdependence between those three groups is shown in figure 1.1

Figure 1.1

Informatics within the Electronic Complex



The definition of informatics industries and their scope varies from place to place. In Brazil, the informatics industry is broadly defined in the law of informatics to encompass most digital related activities. According to Article 3 of law 7232 of 29 October 1984:

> " any activity related to the rational and automatic treatment of information is considered informatics activity, and specifically, those activities regarding:
> I - research, development, production, import, and export of semiconductor electronic components, optical electronics, as well as their respective electronic inputs;
> II - research, import, export, manufacturing, marketing, and operation of machines, equipment and devices based on digital techniques and having technical functions such as collecting, treating, structuring, storing, switching, retrieving, and displaying information, their respective electronics inputs, parts, elements, and physical operation support;
> III - import, export, production, operation and marketing of programmes for computers and automatic information treatment machines as well as the corresponding technical documentation (software)."[1]

[1] **Brazil: National Congress: Law 7232 of 29 October 1984, article 3.**

This apparent contradiction between the definition given in the law, and the organization of national industrial statistics used in SEI reports (SEI, 1982 to 1989) which includes simply the producers of computers and peripherals, poses methodological problems for data collection and research. This thesis uses the employment and trade figures provided by the government and industry associations covering only the producers of computers and peripherals. The geographical survey of the distribution of the industry in Brazil includes producers of computers and peripherals as well as those firms directly involved in the production of parts and components necessary for the functioning of complete data processing systems. Included in the spatial analysis provided, in addition to producers of computers and peripherals, are other sectors of the electronics industry. This is done to illustrate distinct spatial organization and linkages pursued by different sectors throughout the national territory.

I.3.1 Computer Manufacturing

Computers have certain characteristics that are relevant to the discussions that will follow in this thesis. The production of a computer draws from a range of inputs (hardware). The computer itself must be connected with other products (peripherals) and programmed adequately (software) in order to perform its functions properly. The production and marketing of hardware, components, peripherals and software vary greatly.

Computers are both intermediate products incorporated into the making of others (cars, military equipment, consumer electronics, etc...) as well as final goods to be used in the home or office. The wide range of applications and increasing penetration of computers into many aspects of human life make them an appealing product with increasingly large world markets.

Computer producers depend on technology and scientific knowledge to develop new products and open new market frontiers. After years of development, the manufacture of standard equipment has become a possibility for most potential entrants in this industry. However, for non-standard equipment, companies are under continuous pressure to participate in developing and keep up with producing the latest technology. Thus companies most closely involved in, or that can best appropriate, research and development (hereafter R&D) stand a better chance of remaining in business. Adequate state support of national science and technology (hereafter S&T) programmes and

research and development targeted at these industries is, as a result, strategic and determinant in the success of new entrants.

The computer industry has been in existence for less than 40 years. The first computer architecture based on sequential processing was developed during the 1940s at Princeton University. From then on there has been a sequence of five technological phases also known as 'technological generations'. These are summarized in table I.1.

TABLE I.1

TECHNOLOGICAL GENERATIONS IN THE COMPUTER INDUSTRY

Generation	Period	Computer Model	Characteristics	Applications
0	1940s	ENIAC	Not capable of storage programmes. Valve processors.	Basic Calculation (e.g., artillery trajectories)
1	early 1950s	UNIVAC I	Programmes in memory. Programming in machine language Valve processors.	Scientific & Technical calculations. Pay rolls.
2	late 1950s	IBM 7090	Higher languages: COBOL. CPU with transistors. Magnetic memories, data input with perforated cards.	Same as above
3	early 1960s	IBM 360 BURROUG HS 6500	Hybrid ICs (IBM) or Low integration ICs (Burroughs) in CPU. Semiconductor processors.	Real time processing. Greater applications.
3,4 or 5	late 1960s	IBM 370 DEC PDP 11	High integration IC. Growth of mini computer markets. Development micro computers.	Development of specialized applications. Technological convergence with other sectors.
5	late 1980s 1990s	?	Programming in natural languages. Voice recognition. ICs of gallium arsenide.	

Source: International Competitiveness in Electronics
US Office of Technology Assessment, OTA - ISC, 1983.

These five technological periods have been made possible by developments in the microelectronics sectors and have revolutionized the way computers are used. The

sections below look at products and market changes in the industry resulting from the developments in the microelectronics sectors.

I.3.2 Product and Market Changes

Advancements in microelectronics, associated with the reduction in the size of components, have significantly altered the computer industry. Below six aspects of miniaturization are described.

First, 8-bit chips made possible the construction of smaller and architecturally simpler machines: the micro and later the mini computers. These, in turn, have been followed by new telematic systems, robots, industrial automation. The reduction in machine size, its greater acceptability and wider use raised demand, brought costs down and made the computer a mass produced commodity. Table I.2 shows the world market for computers in 1984, in which personal computers represented 26.3% of the total sales, second to mainframes with 33%. By 1987 mainframe sales decreased to 13% of the world market for computers (Vasquez & Zimmermann, 1988). Figure I.2 shows the computer sales in the US market, the leading market for informatics goods, indicating the position of micro sales vis-a-vis the rest. The arrival of microcomputers, and the simplicity of the machine's architecture, also lowered entry barriers to a number of new producers worldwide.

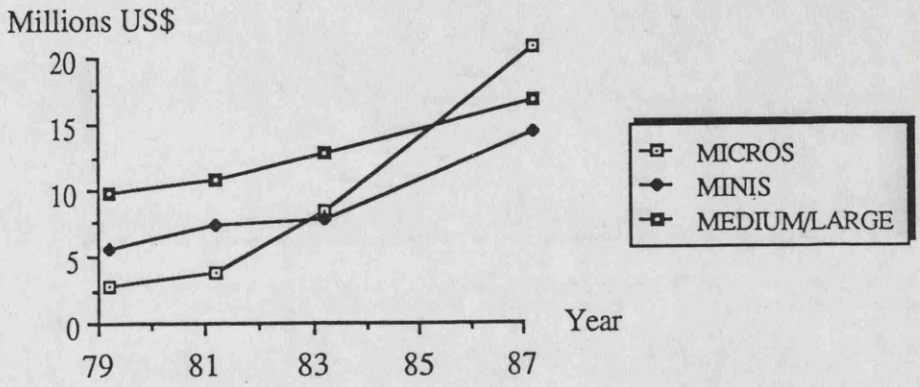
Table I.2
World Market for Computers, 1984

Types of Systems	%
Very Large and Large Computers	33.0
Medium size computers	21.6
Mini and super mini computers	19.1
Personal Computers	26.3
Total	**100**

Source: Delapierre & Zimmermann (1986:77)

Figure 1.2

Computer Sales in the US markets



Source: IDC, Fortune, 9/07/84

Second, new chips used in micro and mini computers are comparable with some existing mainframes (as with the introduction of 16 and most recently 32 bit machines). This blurs product boundaries even if it has not as yet affected nor replaced the role played by large systems. There are a number of applications which demand the handling of large quantities of data (such as meteorological monitoring, real time industrial manufacturing controls, a range of public services, and so on), over and beyond the processing capacity of today's single most powerful integrated circuits. As such, the market for large machines remains and this tends to perpetuate its role as a significant demand pull for smaller units, to complement the performing of their tasks.

Third, developments in microelectronics allow for a reduction in the product life cycle of smaller machines. For each generation of a new chip, computer producers introduce a new model, more powerful and with more features to replace existing ones. Shortening product cycles does not reduce the R&D costs of new products. The relationship of research to product development is a crucial determinant in the reshaping of competition patterns worldwide. Chip producers need to devote large sums of money to the R&D of new and more powerful components. Computer producers do the same, with the hope of launching these innovations ahead of competitors. The faster these new products hit the market the shorter the product cycles of existing goods. Rates of return on capital are affected in these shorter cycles, increasing the risk factors every time a firm decides to launch new, more advanced products.

Figure 1.2

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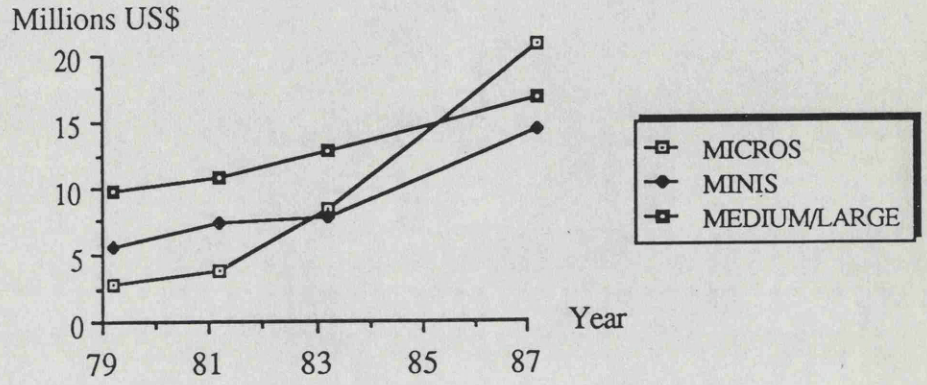

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Second, new chips used in micro and mini computers are comparable with some existing mainframes (as with the introduction of 16 and most recently 32 bit machines). This blurs product boundaries even if it has not as yet affected nor replaced the role played by large systems. There are a number of applications which demand the handling of large quantities of data (such as meteorological monitoring, real time industrial manufacturing controls, a range of public services, and so on), over and beyond the processing capacity of today's single most powerful integrated circuits. As such, the market for large machines remains and this tends to perpetuate its role as a significant demand pull for smaller units, to complement the performing of their tasks.

Third, developments in microelectronics allow for a reduction in the product life cycle of smaller machines. For each generation of a new chip, computer producers introduce a new model, more powerful and with more features to replace existing ones. Shortening product cycles does not reduce the R&D costs of new products. The relationship of research to product development is a crucial determinant in the reshaping of competition patterns worldwide. Chip producers need to devote large sums of money to the R&D of new and more powerful components. Computer producers do the same, with the hope of launching these innovations ahead of competitors. The faster these new products hit the market the shorter the product cycles of existing goods. Rates of return on capital are affected in these shorter cycles, increasing the risk factors every time a firm decides to launch new, more advanced products.

Fourth, new products bring changes in market targets. The mainframe era meant the construction predominantly of large expensive machines to satisfy the needs of very select institutions (namely the government, defence agencies, research centres, and so on). These sophisticated and highly specialized client demands included basic machine maintenance, and software which was custom made to satisfy individual needs. New products are smaller and more user friendly machines and their market is larger, more complex and more demanding. Potential buyers of micros are no longer experienced and informed users but a spectrum of customers demanding greater support services from computer producers and, even more important, from software programmers. The turning of computers into mass produced commodities meant the reorganization of computer production, to use mass production techniques and to achieve economies of scale. "Computer systems become more complicated and diverse and in order to win orders from the new kinds of user, computer firms had to put much more emphasis on marketing, sales and custom support than hitherto." (Morgan & Sayer, 1988). It also fosters the restructuring of the industry's distribution and marketing schemes (dealers, distributors, and so on) to reach the expanding market of new consumers.

Fifth, technological developments in the computer production sector have led to a split between software and hardware production. As pointed out above, the computer depends on a set of software packages that make it operational. As hardware becomes more standardized the demand for different software applications rises. New products developed with greater processing capacity have created a demand for more sophisticated software.

Software can be divided into two types: system and applications. With the first type of software, programmes were written to be executed by machines. In the first years of computer production, machines were only able to process internal, binary languages. Programmes were custom made and were not transferable from system to system, each producer had to provide their own programming. Today software can be produced independently from the computer producer and the type of computer which will execute it. Programming languages are becoming more similar to natural ones, the scope of innovation goes beyond the binary system. The industry is involved in facilitating access to computers with the introduction of 'user friendly' systems (e.g., the Apple MacIntosh architectures) to bring even more users into the market. The second type of software is for applications programmes, oriented to fill the growing

needs of users. Therefore, the greater the utilization of computers in daily life, the greater the demand for complex and diverse software packages. The scope of software production has become so wide that it has become an industry in itself. [1]

Sixth, new products, technological improvements, the widening application of computers (exemplified by the convergence of telecommunications and informatics), and the expanding consumer base paved the way for the demand for 'total solutions'. Total solutions call for well-equipped production facilities and human skills which are put into constant interaction with customers (Morgan & Sayer, 1988). Relevant to the regional focus aimed at here, this new product/service arrangement is clearly spatially-biased. Increasing technological sophistication can only occur where there are R&D centres, production facilities and qualified labour. Regions that can offer (make available) these locational features have a greater chance of being chosen as sites for new investments.

Each technological generation of computer is accompanied by substantial changes in computer production, utilization and distribution. These technological changes have repercussions on both a global (TNC) and national levels.

The following chapters examine relationships between technological changes described above and the emergence and development of informatics. Also highlighted are the relevance of other factors, particularly the role of the state, which are equally important in this process.

I.4 Summary and Conclusions

The development of Brazil's informatics industry has been very uneven, and is dependant on, and influenced by changes taking place in the industry on an international scale. This thesis looks at the relationship between developments in Brazil and those which have occurred elsewhere, and in so doing it examines the constraints to and possibilities for the Brazilian informatics industry to achieve the goals outlined in the second national informatics plan.

This thesis looks at the asymmetries of the development in Brazil and elsewhere, bringing out the spatial and regional perspective of Brazilian development. This approach has not yet been pursued by the relevant literature on the theme. The current literature has asserted the primacy of certain factors (e.g., uniqueness of the national

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[1] Due to technological differences between software and hardware production plus space limitation in this thesis, software is not included in the empirical analysis.

initiative, changing competitive structures of the national industry, the political context of the policy) to the relative neglect of others (e.g., the relationships between industries and localities and the links between the Brazilian experience and that of other countries).

More importantly for a discussion on the relationships between developments in Brazil and those occurring elsewhere are the arguments put forth in the literature on development. The theoretical framework used in this thesis draws from different development theories the elements necessary to explain how the Brazilian informatics industry has developed and grown, looking at the historical and geographical uniqueness of the Brazilian experience.

To examine the international context in which informatics has developed I have looked at technological aspects of this industry. These include the international nature of the industry, the links between informatics and other sectors of the electronics complex, the strategic role of information technologies for private and public sectors and so on. A working definition of informatics as spelled out in the Brazilian informatics law is given and the methodological limitation of this definition explained when it comes to surveying the spatial distribution of informatics in Brazil.

The next chapter outlines the theoretical framework for this thesis.

CHAPTER I

I Is Underdevelopment Pre-determined? Theoretical Perspectives

1.1 Introduction

Authors of different political perspective have accepted industrialization as a precondition for successful economic growth (Corbridge, 1986:129). They have offered different accounts of the pace and place of this economic transformation and of its potential impact on the Third World. This thesis is about industrial development. It focuses on the development of the Brazilian informatics industry and policy. The approach chosen is to look at these developments through an international lens and to demonstrate that the industrial, technological and geographic development aspects of the Brazilian industry are linked to global developments and are uneven.

No single theory can provide a comprehensive framework that brings together development, capital internationalization, role of government and geographical unevenness, the four elements in this thesis. This chapter, therefore, reviews three theories written to explain industrial development of national and transnational informatics industries: development of underdevelopment theories, new international division of labour thesis and regulation theory, and it gives a definition of uneven development based on the work of Smith to explain different levels of social and spatial unevenness (Smith, 1984).

1.1.1 Structure of the Chapter

Many NICs have managed to develop national informatics industries. The emergence of these industries in the NICs contradicted earlier analyses of the possibilities of economic development in the Third World. Section 1.2 examines contributions to the development of underdevelopment debate based on the works of Frank and Wallerstein.

Section 1.2.2 is a critique of these two authors, demonstrating that these theories do not provide a useful framework to understand the recent industrialization processes taking place in the Third World.

The rapid internationalization of capital that started from the 1950s onward offered new food for thought for theoreticians looking for ways to explain development. Section 1.3 reviews the new international division of labour thesis. This theory explains

the relocation of productive capital to the Third World, while putting overdue emphasis on the supremacy of certain factors such as cheap labour and declining rates of profit. Section 1.3.3 is a critique of the NIDL.

Section 1.4 shifts the emphasis from development to focus on the role of the state in designing and implementing industrial development policies. Regulation theory provides a framework of analysis centered on the role of governments as key formulators of social economic development policies.

A prominent argument of this thesis is the uneven development of informatics industries throughout the world and in Brazil. The theories reviewed in the chapter are weak in their conceptualization of uneven development. Section 1.5 explains different levels of differentiation and spatial unevenness, and section 1.6 summarizes and concludes the chapter.

1.2 The Development of Underdevelopment

After the Second World War, scholars of various traditions began to examine the different ways economic development occurred worldwide. The reshuffling of political and economic powers among different nations seemed not to even out countries' standards of living but continued to enhance their inequalities. In the late 1960s a growing body of literature broke away from the ethnocentrism and empiricism of more traditional social science to analyze development (Henderson, 1989:11). The new explanations of the process of growth (or lack of growth) and theoretical frameworks of the dependency paradigm are significantly different from one another (Palma, 1981). Yet they suggest that

> "it is simply not possible to adequately comprehend a vast array of economic, social, and political phenomena in particular Third World countries unless these phenomena are theorized in relation to the changing circumstances under which those countries are structurally connected with the economic and political systems of the advanced capitalist societies" (Henderson, 1989:11).

The realization that development issues had to be examined through a global perspective remains a key factor in subsequent studies on industrialization, and for this thesis.

To illustrate the contribution of the dependency paradigm, this section examines the works of Frank and Wallerstein. These are not the only proponents of this theory. Within the 'dependency theory' or 'dependency approach', there are many distinctions (Larrain, 1989: chapter 6). These extend from a non-Marxist critique, which looks at

dependence as a testable theory (O'Brien, 1975; Lall, 1975), to a Marxist critique focusing on the development of capitalism (Warren, 1980), and to yet another looking at the articulation of modes of production (Rey, 1978). The two contributions explored here fall within a Marxist framework.

a. Frank

Frank's work focused on explaining how some countries managed to place themselves in the centre of political and economic life to control others (Baran, 1967). Frank placed the origins of capitalist social productive relations in the formation of a global economic system in the late 15th century. During this period capitalism spread out of Europe to incorporate the world into a single organic mercantile capitalist system. As capital expanded across boundaries it "destroyed or totally transformed the earlier viable social and economic systems of these societies, incorporated them into the metropolitan dominated worldwide capitalist system, and converted them into sources for its own development" (Frank, 1969:225). Frank saw in these global exchange relations the essence of capitalism.

He argued that the control of certain countries by others - or the perpetuation of underdevelopment - arose from the circulation of capital in its commodity form, and its transference from less development regions of the world (as raw materials) to more developed regions (to be manufactured and resold for higher prices) on the basis of unequal exchange (the different prices paid for raw materials and manufactured goods) (Henderson, 1989:12).

By focusing on the unequal relationships between less developed and developed regions, Frank was unable to understand he called earlier viable social and economic systems. He made no distinction between two economic realities and social structures between less developed regions and developed regions. According to him, development and underdevelopment occur under identical historical and geographical conditions and "could not be the product of supposedly different economic structures or systems." (Frank, 1969:28).

b. Wallerstein

Wallerstein, like Frank focused his work on the roots of development in the more economically advanced countries (Europe and North America) and how it related to development in other parts of the world (Wallerstein, 1974). His conceptualization of space did allow for the capitalist system to expand through world trade. That is, he saw in development of commerce the emergence of new forms of productive organization,

a division of labour, and a regional specialization through surplus transfer and capital accumulation in the more economically advanced nations. Like Frank's interpretation, the driving force behind this system rested on exchange (e.g., trade, commerce) and not on production per se.

Wallerstein also recognized the possibility of genuine development of less developed parts of the world within the capitalist system. He accepted a growing involvement of local capital in the growth process, the emergence of corporations indigenous to these countries, and the movement of this new capital both back to the more advanced nations and/or to other less developed countries.

In explaining these developments Wallerstein moved away from Frank by identifying a capitalist and a pre-capitalist social system in interaction. For him "the social system is of prime importance, and external factors must take precedence over internal factors in accounts of underdevelopment" (Corbridge, 1986:34). He was also able to identify different levels and qualities of uneven exchange between countries, regions and economies. He divided the capitalist world system into three tiers of states, the core, the periphery and the semi-periphery, with the difference between them being determined by the political and economic strength of nation states to put in motion exchange relations.

One shortcoming of Wallerstein's conceptualization of development was to describe it as a series of tiers and spatial regions like core, periphery and semi-periphery. For, as Henderson argues, these are only formal categories that describe and designate particular territorial units in particular historical periods (Henderson, 1989:15). Second, Wallerstein makes no concession to the possibility of the development of the forces of production, technology, or innovation in places outside the realm of more advanced economies. He accepts the possibility of the development of some countries (semi-peripheral units), however, according to his theory, these countries seldom develop organizational and scientific technical knowledge to exercise more control over their development process.

1.2.1 Critique

The 'development of underdevelopment' theories are weak in capturing the dynamics of capitalist development in both space and time, and in concentrating heavily on the global scale alone. The recognition of systematic barriers to economic development in the course of capitalist expansion led to the formulation of theories to

explain obstacles to development.

Frank's and Wallerstein's conception of development places heavy emphasis on the sale of manufactured goods produced with cheap raw materials as the single source of income generation and profit making. According to Cardoso and Falleto, uneven development has to be examined in terms of how productive activities are organized and not on how much money countries can make from the sale of products. (Cardoso & Falleto, 1979). A focus on production exposes different mechanisms used by developed countries to maximize their gains by relying on labour and resources located in less developed regions of the world. It also demonstrates the different types of interaction between less developed and developed regions, the possibility of a gradual transformation of underdevelopment, and the achievement of maximum capitalist development goal --accumulation.

The criticisms of dependency theory do not end here. Larrain in his review of theories of development (Larrain, 1989: chapter 6) argues that dependency or underdevelopment theories are mainly focused on a Third Worldist perspective and ideology. This ideology assumes that capitalist accumulation proceeds in the advanced countries in a relatively uninterrupted manner while the major locus of contradiction is in the underdeveloped countries. This is problematic for, as it will be discussed below, capitalism is uneven even inside the AICs (Chapter two). AICs are a patch of more and less privileged areas with more developed and less developed regions within. In terms of the global informatics industry, areas like Wales, Scotland, Ireland or Spain comprise a so-called European 'periphery'.

Dependency theory is also contradictory in the way it defines development in the advanced countries as a self-sufficient process, yet one which is reliant on the existence of less developed regions. However, if indeed developed countries are self-sufficient they should not be dependent on underdeveloped regions. This functionalist view of dependency underestimates the prospects of some form of a successful capitalist development in selected parts of the world documented by abundant empirical evidence (Chapter three). Lastly, though dependency theory tries to be a critique of modernization, it remains within almost the same frame of reference. Both theories propose a model of development where the Third World is an appendix of the developed world (Larrain, 1989: chapter 6).

Emerging patterns of capital internationalization in the 1960s and the appearance of industries including electronics throughout the developing world inspired many theories of Third World development, some looking at it as a positive and long lasting

phenomenon, others defining it as functional to needs of developed countries (Forbes, 1984). The next section examines the ideas behind capital internationalization and the division of labour thesis.

1.3 Industrialization and Development

A salient feature of advanced capitalism has been the internationalization of capital. (Amin & Goddard, 1986; UNCTC, 1983a; Taylor & Thrift, 1982). Internationalization is understood here as the movement of capital across national boundaries. Capital has from its origins developed internationally. The theories described above confirm that and even explain capital's mobility as a way to set up world markets.

By way of contrast, the contemporary expansion of productive capital and financial capital since the second world war has been marked by its international expansion through transnational corporations (hereafter TNCs). By 1980, 28% of the gross domestic product (GDP) of developed and developing countries was accounted for by the sales of the top 350 TNCs (UNCTC, 1983a). Perhaps more illustrative of the dominance of TNCs is the amount of trade which is channeled through these companies. For example, it has been estimated that up to 40 percent of world trade is in the form of internal transfers between TNC subsidiaries (Taylor & Thrift, 1982). Through the activities of TNCs, capital has extended its role around the globe and with it has come a new geography of production.

An important strategy of TNCs has been the establishment of production subsidiaries in selected industrial sectors (e.g., textiles and electronics) where there are abundant supplies of low wage labour. This is evident in the growing importance of many Third World countries and specially the NICs, in terms of their share of capital growth, manufacturing output and exports (OECD, 1988).

The growth of manufacturing output has been paralleled by a rapid expansion of manufacturing exports to the industrialized countries. The NICs share of industrialized country exports of manufactured goods increased from 1.6% to 9.5% by 1985 (OECD, 1988). As a result, the focus of the academic debate on the internationalization of capital has been on the relocation of productive capital to these low wage sites in the Third World.

This process of industrialization and internationalization affects different countries. The internationalization of capital has a marked spatial bias with the movement of capital among the advanced industrial countries in many instances far out

weighing the shift of capital towards the Third World. TNCs investments are more prominent in selected industries including informatics.

The international division of labour thesis is reviewed below.

1.3.1 The New International Division of Labour and the Internationalization of Capital

The New International Division of Labour refers to the breakup of the bi-polar global capitalist economy (AICs vs. NICs) associated with the era of empires and the increasing fragmentation of manufacturing processes, whereby partial operations are geographically dispersed to capture labour cost savings (Fröbel *et al*, 1980).

Fröbel *et al* argue that three sets of conditions have developed which have given rise to a restructuring of the conditions of valorization and accumulation of capital, and consequently to the restructuring of the international division of labour. First, is the development of a global reservoir of potential labour power. This labour power is characterized by low wages, long working days, high rates of exploitation and limited employment rights. Second, the development of the labour process has led to the decomposition of complex tasks into elementary units thus facilitating the substitution of skilled labour with un-skilled and semi-skilled labour. Through advances in production and job organization techniques that were already being used in manufacturing in the AICs, capital is argued to have a "monopoly of the knowledge related to the control and execution of the labour process", reducing the worker to a mere appendage of the production process (Fröbel *et al*, 1980:35). Third, is the advancement of the forces of production relating to transportation and communications technology which, "...renders industrial location and the management of production itself largely independent of geographical distance" (ibid.:36).

These pre-conditions have generated the *possibility* of a world market, engulfing both the developed and underdeveloped countries, for production sites and labour power and the opportunity for surplus profits. "The overriding pressure of competition turns this possibility into a *necessity* for the survival of any individual capital" (ibid.:44). The consequence of acting upon this necessity is the decentralizing productive activities and the establishment of "world market factories" designed to take advantage of low wage locations from which commodities (including intermediate products) may be exported back to the AICs.

1.3.2 Critique

The NIDL theory tends to over-emphasize cheap and unskilled labour as the central explanatory variable of spatial change. The emphasis on nominal labour costs confuses wage rates and rates of exploitation, the latter of which take into account the varying productivity of labour power. In part, this problem stems from a tendency to generalize the nature of the process of industrial change and relocation based on the experience of a narrow selection of industries at a particular historical conjuncture. More generally, the model proposed by the NIDL theory presupposes a linear conception of product development and particular management practices. Based on these suppositions a logical argument is advanced to suggest the importance of labour cost differentials as the prime determinant of industrial location in standardized product markets. This conception is logically and empirically inadequate.

Logically, even if we accept a linear conception of product development (e.g., towards standardization), it does not necessarily follow that this will mean the production process will become labour-intensive or that decentralization to cheap labour sites will occur. In fact, this is only one possible strategy available to capital to increase the rate of profit. Equally plausible is the application of new capital-intensive production methods such as computer aided design and manufacture (CAD/CAM) and robotics as a means to preserve profitability. In the case of semiconductors, while there has been a tendency to concentrate on labour costs as the exclusive factor governing location dynamics, initial R&D costs, high labour skill to carry out those activities, and the increasing importance of high quality and reliability (non-price factors) of semiconductors, has necessitated more rigorous production demands including quality control. The importance of quality control has in turn stimulated the automation of assembly operations thus reducing the need for labour-intensive assembly (Cho, 1985). Moreover, these differences are not simply reducible to varying organic compositions of capital, also important are the nature of the production process and the specific mechanisms of labour control.

> "The emergence of powerful, effective labour control mechanisms, the employment relations and work organization that maximize the extraction of surplus with little labour-management conflict, has emerged as one of the major conditions promoting the recent return of capital to the United States in the electronics industry. This new development suggests that with automation of production, the cheapness of labour costs for capital has become less and less important." (Cho, 1985:214).

Empirically, a linear model of product development towards mass production and

price competitive markets does not appear to be a useful abstraction in the context of many industries, including informatics. Factors such as political alliances, restriction on the transfer of technology, financing, counter-trade agreements, and non-price forms of competition are at least as important as price factors in structuring locational patterns in informatics markets. This will be demonstrated in Chapters two and three.

Second, there are problems in the way in which technological change is handled in the NIDL theory. Fröbel *et al.* emphasize the importance of the development of the productive forces, in a restricted fashion. The NIDL thesis excludes the tendency of capital to revolutionize the labour process and increase the productivity of labour, that is for capital to accumulate through relative surplus-value production. At the same time the introduction of new use-values and barriers to entry are not given due consideration, although these may have quite profound social and locational consequences. In product markets characterized by rapid product development and/or technical barriers to entry, as is the case in informatics, labour costs are likely to be relatively unimportant as a locational factor.

Further, Fröbel *et al.* see technical change, and specifically the development of the productive forces enabling capital to liberate itself from geographical distance, operating in a unidirectional way, towards decentralized production. The effects of technical development cannot be assumed to operate in this way. More correctly, these effects are two edged. For example, computer network technology allows firms to expand markets by facilitating the rapid conveyance of services and information to dispersed sites. At the same time advanced communications and information processing systems provide control and monitoring capabilities, i.e., centralizing tendencies over hitherto decentralized activities, reducing the "bounded rationality constraints on more complex spatial forms of business organization." (Hepworth, 1987:173).

Third, the issue of demand is equally inadequately addressed, again with implications which can obscure the factors contributing to industrial and spatial change. The convergence of information and telecommunication technology in informatics discussed in the introduction, has led to growing importance being attached to the dynamic interactions between producers and consumers (tailoring products to consumer needs) and creating greater possibilities for industrial agglomeration. The shift in demand from military to civil applications, with a concomitant shift in market dynamics away from non-price forms of contracting to more commercial pricing practices in the semiconductor industry, was associated with the shift in location of the industry towards low wage sites for assembly. Also different institutional structures of demand may have

a very important influence on locational dynamics. IBM is a major chip producer but has not used off-shore assembly operations because of its vertically integrated production structure (Bakis, 1977).

Fourth, the role of the state and its effect on industrialization and internationalization is under-emphasized in the NIDL model. In a study of the motor industry, direct state intervention (through investment incentives and export subsidies), and not cheap labour, was a crucial factor underpinning foreign investment decisions (Jenkins, 1985). The same is true for much of the development of informatics in certain Third World countries, notably in Brazil. The internationalization of capital to most Latin American countries in the 1960s and 1970s faced a number of barriers in the form of national policies of import substitution which prevented the establishment of TNCs owned branch plants. TNCs were thus compelled to expand through licensing and co-production arrangements with host country firms in accordance with government regulations.

To summarize, the first body of theories which are part of a dependency paradigm saw the development of the Third World as an impossible task. Tied to developments of capitalist countries through unequal exchange, Third World countries were to remain forever dependent on them for most of their needs. The second theory, the NIDL thesis advanced understanding of the development process. Drawing from a restricted and historically specific case of a selected group of industries (e.g. textiles, consumer electronics and semiconductors), this model, however, gave evidence and proof that some of the Third World was finally coming out of the trap of underdevelopment.

These theories, however, do not explain two major factors with which this thesis in concerned: the role of the state as agent in the development process operating at national regional and international levels, and the uneven nature of development.

In what follows I review regulation theory's account of the role of political institutions in economic development.

1.4 The Regulation Approach

Regulation theory provides a general framework through which economic development can be conceptualized (Aglietta, 1979; Lipietz, 1982). Given that capitalism is both ridden by, and dependent upon, crises, the regulation school addressed the question of how relatively stable periods of economic growth occurred. Two concepts stand at the core of the regulation approach, these being a *regime of accumulation* and

a *mode of regulation.* A regime of accumulation refers to the "stabilization over a long period of the allocation of the net product between consumption and accumulation; it implies some correspondence between the transformation of both the conditions of production and the conditions of the reproduction of wage earners."(Lipietz, 1986:19). This implies a continual and parallel coordination of both the conditions of production and conditions of reproduction of wage earners. For a regime of accumulation to materialize there must be a corresponding mode of regulation which embodies a set of norms, laws, habits, regulation networks, a "body of interiorized rules and social processes" (ibid., 20), which ensures the unity of the process of accumulation. Using these concepts, an explanation of relatively stable, albeit temporary, periods of accumulation could be advanced, notwithstanding the contradictions of the capital relation and class antagonisms.

According to the regulation school, the post-war period of capitalist expansion was characterized by an intensive regime of accumulation termed Fordism. Fordism was characterized by two historically and theoretically linked phenomena. On the one hand, it was based on radical and constant change in the labour process, combining rising productivity and an increasing technical composition of capital. Within the labour process, the gap between conception and execution of work was created as capital sought to "...systematize the ever new content of workers' skills, and to ensure capitalist control over it by hunting down the 'free space' left in the labour process." (Lipietz, 1982:35). On the other hand, Fordism involved the continual adjustment of mass consumption to rising productivity. This linking of production and consumption was established through monopolistic forms of wage regulation (such as cost-of-living and productivity linked wage settlements), thus facilitating the realization of a rising mass of value. The link between wages and expanding production was further complemented by the development of particular institutional structures, consumption patterns and modes of state intervention. Crucially, Fordism could only temporarily offset the contradictions and tendencies towards crisis of capitalism.

By the mid-1960s the pace of expansion slowed and productivity stagnated. Fordism had seemingly reached its technical and social limits. Fordist accumulation was predicated on rising productivity which offset a rising organic composition of capital and limited the share of wages in total value impinging on profits. Increases in wages necessary to maintain the realization of surplus-value became counterpoised to declining profit rates, and a profitability crisis ensued. "For capital in general...the problem is not so much to find markets as to drive up the rate of exploitation."(ibid., :36), as a

means to realize surplus value. Along with technical and social limits to expanded reproduction of capital within the regime of Fordist accumulation, the corresponding modes of regulation which governed this also reached their limits.

Responses to the crisis of Fordism may be seen along two lines: capital restructuring *within* and *along* Fordist lines; and capital restructuring along a post-fordist trajectory. At this point I will confine myself to the former since much that has been written on the process of internationalization has developed these arguments. Two ways in which capital has attempted to ameliorate profitability crises within Fordist lines have been, "... a quest for gains in productivity and a search for cheaper wage-zones."(ibid.:37). Each strategy has important and distinct implications. In terms of the former, to the extent that productivity increases under Fordism are linked to mass production and scale economies, national capitals sought to broaden consumption through greater international trade within the AICs. In effect, there was a move towards greater integration and interdependence amongst AICs which will be discussed in greater detail in Chapter two. At the same time, the search for cheaper wage zones brought about a different spatial structure of accumulation. In particular, there was an internationalization of productive capital to other countries, whereby branch circuits of Fordist production systems are spread "over a pool of unevenly skilled and unevenly paid workers."(ibid.:37). In some ways this ties in with the NIDL thesis in explaining the movement of capital across international boundaries, even if the reasons for such movement are explained differently.

The basis of this Fordist capital mobility lay in the disjunction in the labour process between conception, skilled production and unskilled assembly, each of which offered distinct spatial possibilities. The more advanced elements of the labour process remain largely tied to the AICs. To a lesser extent in the case of skilled production, they may however be found in a few NICs. However, given the crisis of Fordism, the possibility of restructuring the spatial organization of production to take advantage of low-wage labour for labour intensive unskilled assembly led to the decentralization of productive capital in order to realize opportunities of increasing the rate of exploitation. At first, this process of internationalization was mainly confined to labour intensive and low organic composition industries run along Taylorist, or 'bloody Taylorist' principles.[1] Later, there was an internationalization of capital designed on the one

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[1] Taylorism basically refers to the fragmentation of the labour process into simple repetitive tasks and is frequently associated with textile and electronics assembly operations. Bloody Taylorism refers to the extremely oppressive conditions under which these activities are organized particularly in the periphery

hand to penetrate local markets and, on the other, to establish low-wage production centres for components for re-export to the AICs.

1.4.1 Critique

Regulation theory recognizes that capitalism is a relation of class struggle yet the analytical categories used separate struggle from structure, subordinating them to a structural logic (Jessop, 1982:149). Regulation theory hopes to question the survival of capitalism when the capital labour relation itself contains and leads to a continuous crisis that tends to hamper the process of capitalist accumulation. The way to understand how the dialectical relationship of capital and labour was in fact made operational was by the identification of specific institutional forms, societal norms, and patterns of conduct that concurrently expressed and represented capital labour conflicts up to inevitable moments of crisis or the mode of regulation of capitalist growth.

Regulation theory emerged, as did previous theoretical contributions, as a critique of NIDL theories (Lipietz, 1982, 1986). Concerned with the historical processes of transformation of societies and the logic of their development, regulation theory opposes both the neo-classical idea of general equilibrium and the orthodox Marxist conception that the development of the forces of production is the principal determinant of capitalist evolution (Silva, 1988:25).

Regulation also rejects a bi-polar interpretation of 'North-South' put forth by the development of underdevelopment theorists where economic relations were based on an unequal exchange of manufactured goods from the North and primary goods from the South. It offers, instead, a methodological framework that avoids falling into dogmas of universal concepts (e.g., imperialism, dependency, periphery) to pay closer attention to the level of the nation states (ibid, 1986).

Economic, social, and political variables are equally important for the regulation approach. This is crucial for this thesis as the type of analysis I propose here intends to bridge the gap left by a literature that has focused too heavily on economic, or political, or technological issues alone. Regulation theory is based on the analysis of a historical perspective. On one hand, this focus on history makes the regulation framework quite flexible in explaining the changing character and nature of capitalist development through time and over space. On the other, it lacks some sort of "consistent framework for the understanding of contemporary relationships, once historical analysis is not the

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(e.g., inside export processing zones).

core of the study" (Silva, 1988:30), but is formulated only to provide the contextual background to explain the present. Despite these bottlenecks, regulation theory seems to provide a unifying element to what often appears to be isolated outcomes, or as Lipietz puts it: "the reconciliation of national and of global regimes of accumulation which are two aspects of the same thing depending on the perspective taken" (Lipietz, 1986:22).

Next follows a discussion of uneven development.

1.5 Uneven Development

This section centres on the uneven nature of capitalist development. As mentioned above, most development related theories have great difficulty in dealing with the unevenness of capitalist development. For as capitalism has developed, it has done so with a clear spatial bias. The informatics industry is one example of this, as will be demonstrated in the next chapters.

The three theories reviewed above conceptualize spatial change differently. In the case of the development of underdevelopment theory the movement of capital between regions is reduced to trade relations between and within regions to satisfy the consumption needs of richer countries. Frank did not allow for much change between regions of the world let alone within them: according to him capitalist development divided the world into a less developed one that existed to provide raw materials, and a developed one that lived off the former. Wallerstein, in turn, identified different layers of development with countries occupying a position among the developed, the semi-peripheral or the peripheral. He argued, however that semi-peripheral countries experienced great difficulties in sustaining their national development plans. Also like Frank, he argued that these distinctions existed between countries and never within them.

The NIDL thesis explained the relocation of capital to Third World countries as a strategy for saving on labour cost. Regulation theory, in turn, aims to explain the crises and booms of capitalism. The spatial explanation of crises and booms is defined within and along fordist lines. In the first case, restructuring can be partly carried out through relocation as a cost saving device. In the second case, restructuring can take place inside the AICs through the adoption of more capital and technology intensive methods.

Unevenness, or the asymmetry of the development process, has to be dealt with at a global, regional and national level, for each level poses different challenges and

brings different constraints for those countries and industries trying to develop.

According to Smith the logic of capitalist unevenness lies in the struggle to achieve the optimum levels of production, marketing, and profit. Profit is by far the most important criterion by which the success of any development process is measured. To achieve maximum profits capitalists are continuously seeking the best balance between market demands and production capacities. And as argued in regulation theory, while the main objective of capitalism is accumulation and growth, this process of accumulation is itself uneven, being characterized by a continuous sequence of crisis and recoveries occurring in different sectors and scales.

The economic history of the industrialized world and, to a lesser extent, that of developing countries invokes different cycles of investment and disinvestment, with certain places being developed at the expense and underdevelopment of others. Chapter two describes the main features of 30 years of economic development in the industrialized countries and how they influenced the development of informatics industries in the AICs. Likewise, Chapter Three illustrates different stages of development pursued by some of the NICs to seize global opportunities to develop national informatics industries. All these accounts come to illustrate cycles of growth and decline that have shaped development worldwide.

Smith has identified different levels of unevenness between capital and labour. To explain these levels he proposes a model that superimposes divisions of labour and capital. These differences are summarized in the table below.

Table 1.1

	DIVISIONS OF LABOUR	DIVISIONS OF CAPITAL	OUTCOME	TYPE
A	General division of labour (e.g. between agriculture & industry)	Division of capital into 3 departments Department I - means of production Department II - individual consumption Department III - collective consumption	General societal division of labour & capital into departments	town & country distinct ions.
B	Particular division of labour (e.g. the sub-sectors within the general divisions)	Division of capital into sectors (e.g. textiles, steel, airspace, electronics..)	Division of labour & capital into particular sectors	spatial unevenness
C	Detailed division of labour (e.g. distinctions among different work processes)	Divisions of capital into individual units (firms).	Divisions of capital between individual capitals	spatial unevenness
			Detailed division of labour within the work place	social unevenness

Source: After Smith, 1984: 106-108.

In this table, Smith identifies three levels in which to observe unevenness. Differentiation occurs in all levels, however, these have both a social and spatial context to them.

In the first case, the *general* division of labour has been historically determined by the division between agriculture and industry, with a spatial or territorial dimension found in the dichotomy of town and country. Given recent developments, this differentiation no longer holds true for many developing and developed countries. Also such a general scale is not fundamental in determining patterns of spatial differentiation.

The division of capital into departments has however, influenced territorial differentiation at an intra urban level. It remains, nevertheless, an insufficient explanation for why certain regions are developed and others are not. Amin tried to demonstrate the discrepancy between the less developed world and the advanced industrialized nations in terms of a departmental division between the two. He gave up this analysis since concrete developments in some of the LDCs and NICs indicated that it was no longer possible to associate the latter as sole producers of department II

goods, and the AICs as producers of department I and III goods (Amin, 1974; Smith, 1984:112-3). Above, in the review of Frank and Wallerstein it was also demonstrated that their conceptualization of dual systems no longer served to account for economic developments in many countries.

Differentiation is most obvious at urban, national and global scales at the level of individual and particular capitals. First, individual capitals concentrate and centralize in one place at the expense of others. Second, there is constant movement of individual capitals from one sector to another in order to maintain and increase the rates of profit. This point will be discussed again later.

The last level, that of the *detailed* division of labour is a technical necessity dictated by the instrument of labour itself (Smith, 1984:109). Differentiation on this level is due to technical development of the instruments of production which contribute to a form of social differentiation and is generally restricted to the domains of the factory, or the work place. Although the *detailed* division of labour has little relevance to the macro implications of spatial unevenness, understanding it is essential to understand the geography of production. The specificities of the labour process vary from product to product and market place to market place and cannot be transferred across borders or resolved by technological innovation.

Spatial unevenness is best perceived, therefore, at the levels of individual and particular capitals. To further explain the continuous economic rise and fall of regions Smith develops a framework based on Vernon's product cycle theory (Vernon, 1966). Smith's cycle, however, is centred on profit. This profit cycle is defined in terms of spatial dimensions of capital movement between sectors and regions of the world (Smith, 1984:113).

While the continued movement within and between different sectors of economic activity is a necessary condition to keep the rate of profit high, the concentration of many investors, capitalists and resources in selected and deemed profitable sectors poses barriers of growth. Being in a situation of competition with other capitals (e.g., industrial sectors, products), investors are compelled to move avoiding the risk and reality of falling rates of profit. Since competition takes place at the level of individual capitals, for firms to survive in the market place they must always be alert to keeping up their competitive role. Technology becomes the crucial element leading individual capitals to seek new product and process technologies (that can be developed by them or appropriated to their own benefit), to set up and invest in R&D centres as a way to maintain their technological leadership. In sum, according to Smith, the driving force

of capitalism, accumulation and growth, is a competition for survival of the fittest. Those countries equipped with capital, resources (human, natural, technical), will manage to stay ahead and those who are at a disadvantage will eventually lose.

Smith, however, abstracts from what he calls the "empirically messy historical conditions upon which capitalism seizes, and in part produces unevenness" (Smith, 1984:155). This abstraction results then in a reductive position that overlooks the particularities of history and geography, and that clearly sees no possibility for development. He says:

> "Empirically, however, and despite the dramatic industrialization that has taken hold in the 1970s in selected Third World economics, a general and sustained industrialization seems unlikely. This kind of restructuring is, so far, blocked by inherent patterns of capitalist accumulation." (Smith, 1984:158).

1.6 Summary and Conclusions

To conclude, this chapter examined different theoretical explanations of industrial development in the Third World. These theories: the development of underdevelopment, capital internationalization and regulation theories have been selected and critiqued for their representativeness of each of these debates. They are not, however, the only theories that have dealt with the issues listed. They provide a small but relevant portrait of distinct interpretations of the development issue.

Some important themes emerge from this theoretical chapter which will inform the discussions developed in Chapters two to seven.

First, it is no longer possible to comprehend development in particular countries unless this is done in the context of a country's political and economic links with the rest of the world. This international perspective put forward by the three theories reviewed in this chapter is evident throughout this thesis.

Second, studies of development should focus on the development of productive (economic) activities in the developing countries. A focus on production reveals ways to develop or to not develop social relations in a given country. Frank's and Wallerstein's work, although relevant in some respects have placed heavy emphasis on trade and commerce between regions. The emergence of the NICs in the latter part of the 1960s suggested that capitalism was developing on its own account in selected places within less developed countries in the world. These developments contradicted the interpretations of the development of underdevelopment thesis and demanded new interpretations of the processes. Relevant points of the technological evolution and

production of computers were summarized in the Introduction. This focus on production is central in Chapters two and three which examine the experiences of the AICs and NICs, and in the review of the Brazilian initiative in Chapter four.

Third, capitalism is ridden with crises and booms. The economic history of the past 100 years shows the rise and decline of regions, countries and economic activities throughout the world. These changes cannot be explained solely in terms of falling rates of profit and cost saving devices.

Fourth, an important theme permeating throughout this thesis is the role of the state in formulating and executing industrial development policies. This chapter states that no single theory can grip the totality and complexity of processes occurring worldwide and in particular industrial sectors. New capitalist realities are embedded in a broad set of institutional and economic processes. They are manifested by new forms of social/economic organization tied to a system of nation-states, by changes in the existing international divisions of labour, and by an overall reorganization of industrial activities in both the developed and developing world. Both dependency theories, and the NIDL neglect the role of governments in development. Regulation theory identifies the ways in which different national systems are influenced by global development. The framework offered in regulation theory is useful to analyze different forms of exchange between countries and TNCs, which are so important in the informatics sector. These articulations are used by countries trying to set up national informatics industries, it is used by those trying to position themselves in the industry's division of labour, and to maintain a level of independence (e.g., industrial, technological, market) from leading companies in the sector (e.g., IBM). Regulation theory also has some limitations-- its macro-economic nature which does not explain how processes occur at specific localities and under specific conditions.

Fifth, another important argument made here is that most of the industrial studies, and accounts of the Brazilian initiative, and for that matter, most of the literature on development of informatics industry in the NICs, treat industrial development as an economic field void of a spatial dimension. Using Smith's conceptualization of different levels of unevenness table 1.1 shows which levels are most directly related to spatial and social changes. According to him spatial unevenness, or the existence of regions with high concentration of profitable industries and of declining regions is explained by the continuous movement of capital from low profit sectors (e.g., electric industries) to high profit sectors (e.g., electronics production), and within sectors (e.g., from production of hardware equipment to the production of industrial

automation machinery) following a capital profit cycle. Broader divisions such as the one between agriculture and industry and between departments (production of public consumption goods and goods for individual consumption) can no longer be used to explain uneven development processes. Smith's work on uneven development however, is set an abstract level. He does not see the possibility of development in less industrialized countries.

The following chapters examine empirically the development of Brazilian informatics looking at it from a global perspective. This global focus aims first to locate the Brazilian industry in an international economic context subjected to the vagaries of the world economy. Nearly half of Brazil's domestic informatics market is controlled by TNCs. This is a significant proportion for a market of an estimated value of 5.4 billion dollars (SEI, 1989). Second, to complete this international perspective Chapter three reviews industrial developments in the NICs. Third, with an international perspective in mind, and the realization that global, national and local industrial outcomes are different manifestations of the capitalist process, Chapters four to seven analyze the Brazilian experience.

CHAPTER II

II Informatics: An International Complex

2.1 Introduction

This chapter examines the main features of Fordism and three different industrial development regimes for informatics: an American one that started in the 1950s with the first internationalization strategies, a Japanese one that began to take shape in the late 1970s, and an European one, consolidated in the late 1980s primarily as a response to the growing Japanese and American presence in the European markets. The chapter also reviews the impact of changing patterns of competition on labour markets and on industrial collaboration.

This focus on Fordism follows a framework developed by regulation theory focusing on the interdependencies of political, technological and economic issues in the development equation (Chapter one, section 1.4). It also looks at the position of large transnational corporations. TNCs are the major force behind internationalization. They determine the patterns of competition and in a way (particularly in the case of IBM) define the environment in which other firms operate (Morgan & Sayer, 1988).

The nature and significance of TNCs' strategies to maintain and expand their share of the international market in this sector and to transform the industry's international division of labour is important in this process. In contrast with the NIDL thesis' interpretation that TNCs' relocation was essentially a cost saving strategy, it will be shown that these companies do not operate in isolation. Leading firms have been able to gain a grip on world market shares by relying on their national economic environments.

This chapter is the first of six which provides empirical evidence to support theoretical arguments outlined in the Introduction and in Chapter one.

Recapitulating, the Introduction presented the object of study of this thesis - the uneven development of the Brazilian informatics industry and policy. To substantiate the argument that unevenness reflects both the nature of capitalism and the relationship between the Brazilian industry and that of AICs, it discussed the role of technological change in industrial development, and particular technological features of computer production. From the discussion it is clear that technology alone cannot explain the

development of informatics worldwide. The driving force behind the development process is economic and the emphasis given in this thesis is on the development of productive activities (industries) and not on trade *per se*.

Chapter one reviewed theoretical perspectives concerning economic development and capital internationalization. Contrary to arguments put forth in dependency theory, industrialization in the NICs gives evidence of possibilities of development of many parts of the Third World. Theoretical interpretations of these developments are, however, problematic. The NIDL thesis overemphasizes the internationalization of capital as a means to save labour costs. It does not take into consideration the role of governments as actors in the development process. Regulation theory is centered on the role that states play in the development of informatics industries and, on the economic, political and technological linkages (or non linkages) evident between these.

2.1.1 Structure of the Chapter

The patterns of capital internationalization in the global informatics industry have changed through time. Section 2.2 examines major technological and political events leading to the present structure of competition in the informatics industry.

Following the regulation approach, section 2.3 looks at the three distinct industrial regimes which have been used to promote the development of informatics in the United States, Japan and Europe, and focuses on the role of governments in designing strategies to meet their national needs for informatics.

Technological change and capital internationalization in this industry had a distinct impact on labour markets throughout the AICs. These changes are reviewed in section 2.4.

Section 2.5 focuses on more recent strategies pursued by governments and TNCs to maximize growth opportunities in an industry that has already reached a certain level of maturity. These new strategies include different forms of national and international industrial collaboration schemes in R&D, marketing and production, and it is centered around the experience of the European Economic Community. Section 2.6 summarizes the main points of the chapter regarding the development of informatics in the advanced industrialized countries.

2.2 Changing Patterns of Capital Internationalization

This section summarizes patterns of competition in the informatics industry for the past 30 years.

Patterns of competition in informatics worldwide reflect shifts in the industrial and technological power among nations and regions of the world. These shifts or changes are the result of important developments in microelectronic technology which have affected computer architectures. These developments have been summarized in the Introduction and in table 1.1.

The development of the computer in the USA marked the beginning of the informatics industry. By the mid 1960s, American corporations like IBM and Burroughs began to internationalize and to consolidate their activities beyond national boundaries. Since then, these companies have transformed the structure of the informatics industry worldwide through becoming TNCs. (UNCTC, 1983a).

For 15 to 20 years, America's development and growing control of the new informatics technologies brought different reactions in different countries (EEC, 1985). America's industrial and technological power threatened Europe's national industries. The emergence of new computer technologies in the late 1970s developed by American based companies happened at almost the same time as Europe's geo-political and economic decline. Many European countries were experiencing problems of deindustrialization and job decline and loss, and of necessity they began restructuring their productive capacities in response (Gordon, 1988). As discussed in Chapter one the restructuring of economies in the late 1970s and 1980s included both the internationalization of segments of the productive process (as labour cost saving devices, for example), or through the introduction of new management techniques, new technologies, and other technology intensive processes.

Informatics technologies offered many possibilities of helping in the process of restructuring of European economies and at the same time informatics was regarded as a new and profitable sector for investment. To counter American expansionism, the European response was to put together different types of industrial policies, as in the case of France in the 1970s (English & Watson Brown, 1985). Some of these policies will be discussed below. However, even if apparently powerful, these policies alone could not 're-industrialize Europe'. These countries had limited and/or inadequate industrial and technological resources for reindustrialization, and their internal markets

were not large enough to compete with those of American corporations (Arnold & Guy, 1986).

American industrial expansion afforded Japan the opportunity to capture the technology needed to develop its own industry. Starting with the consumer electronics sector, by 1970s the Japanese had destroyed American hegemony in the consumer electronics market by using different forms of technological transfer like reverse engineering and original equipment manufacturing (hereafter OEM) agreements. At the same time Japan conquered the American RAM (Ready Access Memories) markets in the early 1980s. In 1981, Japan consolidated its position as a major world competitor with the announcement of the 5th generation R&D project. (Arnold & Guy, 1986).

For the NICs, the expansion of American capital, which included that of electronics industries, had multiple effects. To a few countries it appeared to bring to an end the problems of underdevelopment and to trigger a process of industrialization and economic growth in these regions (Bernstein, 1979; Warren, 1980). However, to the vast majority of Third World countries, including NICs, it made little difference. Capital in the form of foreign direct investment and TNCs was not free to and *would not* go anywhere. Internationalization was dependent on a particular set of political, economic and locational pre-requisites. American capital investments did relocate to a few East Asian countries. Another handful of Latin American countries joined the high tech development bandwagon. Chapter three explores in greater detail industrial development in these geographical locations.

A few years before the launching of the Japanese 5th Generation project (late 1970s), American industrial and technological hegemony began to reach the limits of its growth. This process of American decline is connected with a broader process of capitalist decline which has come to transform social and political economic structures worldwide (Bluestone, Harrison & Baker, 1981; Harrison & Bluestone, 1982; Martin & Rowthorn, 1986). These transformations have been identified by two observers as part of the new historical realities of capitalism emerging in the 1980s (Scott & Storper, 1986:3).

Following regulation theory's concept of regime of accumulation, Scott and Storper have analyzed the main features of Fordism in the 1980s (see Chapter one section 1.4) and a possible transition to a post-fordist one in the 1990s. The transition from one industrial development regime to another is far from linear and varies across

industries and countries. The rise of a new model of growth or of a new regime of accumulation is also a point of theoretical dispute in development literature (Castells, 1989; Cooke, 1989; Harvey, 1989).

In what follows I summarize key issues that have affected capitalist development in the last decade. This summary will provide a global economic background for an examination (in the next chapters) of NICs and in particular of Brazilian industrial strategies and political choices regarding the development of a national industry, and the flexibility (or rigidity) of the Brazilian model to accommodate global changes to its greatest benefit.

* From the late 1950s to the mid 1970s the world experiences an economic boom of global dimensions.

* This boom is characterized by a commitment to Keynesian macro economic policy and other mechanisms such as oligopolistic pricing policies and the eminence of a military industrial complex. The American case discussed below will reinforce this point (section 2.3.1).

* Contributing to the boom is the rise of many NICs as investment sites, the expansion of large world labour markets, the growth of internal domestic markets in the NICs and the development of selected industries in the NICs. These processes have been theorized in the NIDL thesis in Chapter one.

* One of the boom's most significant features is the internationalization of social and economic relations to an extent never before known. Many large industries relocate part of their production activities to the NICs. Investment flows tend to favour AICs - AICs in direction rather than AICs - NICs, NICs - NICs and even less NICs - AICs.

* The very success of the boom creates the conditions which undermine its advance. Market saturation and industrial overcapacity both in the USA and in Europe are intensified with the rise of Japanese growth through exports. Falls in profit vary across industries and countries. Falling rates of profit force capitalists to seize new opportunities for growth which, according to Smith include turning to new industrial sectors that are more profitable, or creating new productive opportunities (Chapter one, section 1.5) Smith describes this process of capital movement between sectors and within sectors as uneven and as part of a system that generates its own crisis (Smith, 1984).

* During the transition from boom to crisis TNCs relocation and investments do not necessarily lead to a real development of indigenous industries in the NICs. Latin America reacts with the introduction of a new round of selected import substitution policies (late 1970s) to curtail TNCs activities inside national territories, as Brazil has done with informatics. A few years later (early 1980s) South East Asia matches export promotion policies with industrial and social polices to upgrade labour skills, to secure technological transfer (e.g., through reverse engineering, subcontracting contracts) and to expand production beyond the boundaries of domestic markets (e.g., economies of scale).

* Globally, the crisis is marked by the rationalization of production systems in old industries, which in many instances are followed by plant closures, job loss, and capital flight. The timing of this varies from country to country. Britain, the US, France, Italy and West Germany all experience differentiated forms of economic and social stress. The NICs are affected by the same processes in the early 1980s, even Japan feels the crisis in the late 1980s (Martin & Rowthorn, 1986).

* Outcomes of the crisis vary significantly across industries and countries and reflect a process of capital reorganization to cope with declining and stagnant rates of profit. Opportunities for restructuring along Fordist lines include the intensification or extension of Fordist practices such as standardization, scale economies, higher wages and intensified consumption (Lipietz, 1982). Alternatively, restructuring along a post Fordist trajectory includes the development of new production processes based on economies of scope, flexibility, the use of new process and product technologies and new kinds of international labour relations. It also includes new location demands. New versions of foreign direct investment include both the establishment, *and not only the relocation* of assembly plants and R&D centres, most inside the AICs. Both in Europe and in the USA, firms begin to engage in new industrial consortia consisting of project specific alliances and a greater commitment to collaborative ventures. These issues will be explored in greater depth at the end of the chapter (section 2.5).

* For NICs and the Third World at large, the prospects for continued

development are bleak. Some are faced with serious debt problems as a result of the oil crisis and the financing of their industrialization by private American and European banks during the 1970s. National productive systems, like the Brazilian one, reach a point of saturation and are in urgent need of restructuring, modernization and expansion (Barros de Castro & De Souza, 1985; Suzigan, 1989).

* In the sphere of the informatics industry, by 1981, during the peak of the crisis, Japan launched a project to push its participation in the technological race, the 5th generation programme to build computers and intelligent systems. Revolutionizing in two ways, the 5th generation project was based on the application of artificial intelligence which enabled computers to mimic aspects of human intelligence together with the application of parallelism to the design of computers. That is, a new system that allows machines to process larger amounts of information in parallel (Arnold & Guy, 1986:4).

* The Japanese challenge, like the American development of computers 20 years earlier, triggered an unparalleled reaction world wide. American industry was shocked with the Japanese ability to close the technological gap, given that Japanese industry had been oriented towards economic, not military concerns. The American industry reacted with an equally powerful project 'Star Wars', as they became more aware of Japan's growing industrial and geo-political importance.

* Also in the 1980s, the European response came 'en bloc', as a result of the lack of success of many of the region's individual efforts, leading to European realization that countries could not do much individually. ESPRIT and a series of other European related programmes came to represent the region's efforts to counteract Japanese moves. The EEC experience will be examined below (section 2.5.1).

* For the NICs, however, the new technological perspectives in electronics and the overwhelming dominance of the international market by competing American, Japanese and European based TNCs came to threaten national hopes of reducing the technological gap, keeping their position in the industry's international division of labour, and of gaining new market shares. Growing international competition puts at a risk achievements to date in selected NICs,

calls for tighter articulation of national interests with the international industry, and for the restructuring of some of these industries (Dalapierre & Zimmermann, 1987). This will be demonstrated for the case of the NICs (Chapter three) that of Brazil (chapters four to seven).

* To conclude, technological, economic and political changes in the informatics industry, changes in the world economy following the crisis of Fordism, and changes in geo-political power of nation states have affected and continue to impact upon the development of national industrial complexes. Countries that have been most successful industrially have been sensitive to these global changes.

New electronic developments such as the 5th generation project have an impact on the functioning of national industries, bringing new demands to existing competitors and to NICs trying to develop their informatics industries. It is clear that having a degree of control over aspects of industrial and technological production processes is particularly important for countries trying to succeed in the informatics race. First, the rapidity of technological change calls for a continuous readjustment of policy to accommodate such issues as emerging industrial areas, new products, new markets, new consumer demands. Second, the informatics industry is an expensive industry. "The ability for countries to participate effectively in this industry is closely related to the amount of money the players have at their disposal", thus, "small countries and less developed countries have difficulty in keeping up, and are obliged to develop specialized survival strategies or to bend the rules of the game" (Arnold & Guy, 1986:6). Third, as a consequence of the previous two aspects, entry barriers are higher than ever, often above the capacity of single companies and sometimes countries to enter the informatics race.

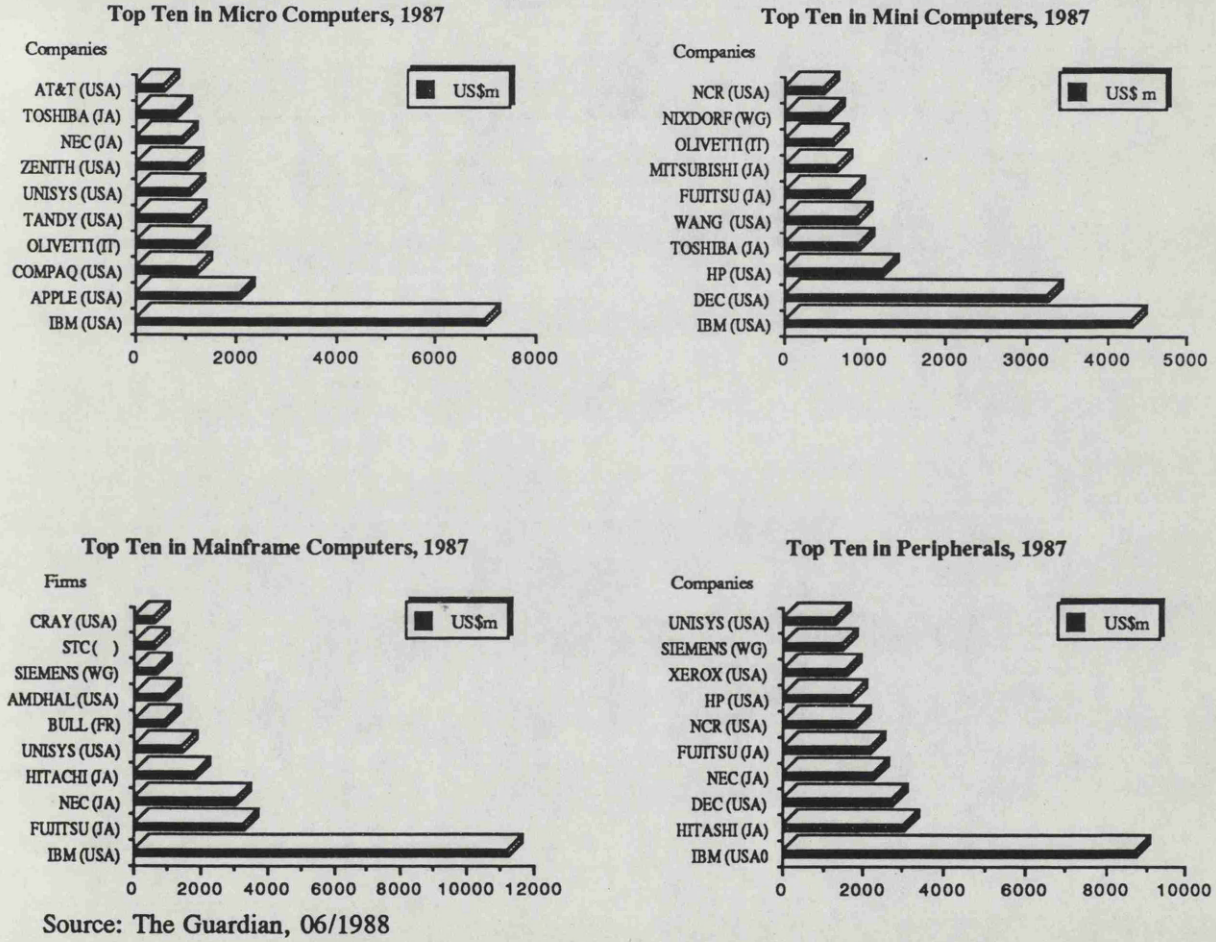
Illustrating the above, Figure 2.1 shows the position of leading world corporations in four market areas in 1987. The basic structure of the global industry has been almost unchallenged for nearly two decades. American corporations, such IBM, have retained a firm grip on their market shares. Reflecting the latest technological and industrial developments, Japanese firms (e.g., Fujitsu, Hitachi, Nec and Toshiba) are now challenging the American hegemony. A separate list of the leading non-US companies indicates that among the top 20, eleven are Japanese, and two are from West Germany (Siemens, Nixdorf), one from Italy (Olivetti), one from France (Bull), one

from Belgium (Alcatel), one from Sweden (Ericsson) and one from Switzerland (Inspectorate) (Datamation 100, 23/06/88).

The following section examines three different industrial development regimes that have competed from 1950s to the present for greater technological and market control of the informatics industries worldwide.

Figure 2.1

Top Ten Industry Leaders Per Market Sector, 1987



Source: The Guardian, 06/1988

2.3 Competing Industrial Development Models

2.3.1 The American Model - 1950 to late 1980s

The electronics revolution began and developed in the United States through the activities of American firms inside and outside the national territory. A summary of technological developments in this sector is found in table 1.1 in the Introduction. The Americans explain the process of capital internationalization of American based firms as a result of natural market forces rather than a result of state led strategic plans (Cline, 1987). Not only do they claim not to have any form of industrial policy to

coordinate economic activity within the country but they often accuse Europe, Japan, and even countries like Brazil of being guilty of strategic targeting of their industries to the detriment of American interest in these markets (English & Watson Brown, 1985:71). Liberal ideals, and what is defined as a 'hands off' approach to the private sector, give the impression that the economy is self regulated by the invisible hand of the market (Cline, 1987:23) It will be shown, however, that the government has had a crucial role in promoting the development of a national informatics and electronics industry inside and outside the United States through its prioritizing of defence concerns.

It is difficult to separate America's role in the informatics industry from that of its defence related activities. Defence is the major building block of the American economy. Since the base of government activities is centered around the issue of a national and international defence, and electronics and informatics can be used in both civil and military markets, government activity tends to spill over into the civil sector as well.

The importance of defence is so great that government strategies even have an extraterritorial dimension to them as a means to prevent the spread and diffusion of strategic technology to other parts of the world. This extraterritorial influence is enhanced by the spatial expansion and overwhelming presence of American based TNCs over the world, and by the criteria used to decide to whom they sell and license their technology and their products.

> "The maintenance of a strong military-industrial complex acts as a channel for (Keynesian) economic policy and underpins American foreign policy. Technology superiority is a powerful economic and military weapon, so American policy strives both to create advantage and to prevent it leaking away through technology transfer." (Arnold & Guy, 1986:34).

Thus, US refusal to sell electronic technology to France in the 1960s prompted the French government to formulate specific policies to procure the technology through other means (Delapierre & Zimmermann, 1986). More recently, the American government banned the sale of a Cray supercomputer to the University of London arguing that the machine could be used for purposes other than academic research (Financial Times, 18/05/87). The ban eventually was removed and exchanged for a guarantee that the computer would not be used 'improperly'.

The distinction between defence and civil markets is important (Arnold & Guy,

1986:34). The US government, represented by the Department of Defence (hereafter DoD), formulates very strict policies which are centrally coordinated and targeted at selected programmes. US Government R&D projects aim to develop entire systems (e.g., in aerospace), rather than single products or process technologies. The development of these complex projects demand financial, human and scientific resources that exceed the capacity and resources of single firms. Single firms are therefore brought together to produce whole systems.

The institutionalization of American military interests occurred in 1958 with the creation of Darpa *(Defence Advanced Research Projects Agency)*. Darpa's main aim is to advance American technological frontiers. Darpa has various basic and applied research programmes under its supervision and a budget of US$ 864 million (1984) distributed between industry and academia. To achieve its aim, the agency controls some of America's most prominent projects like SCP (Strategic Computing Program) the VHSIC (Very High Speed Integrated Circuit Programme), and SDI (Strategic Defence Initiative).

SCP focuses on artificial intelligence for military purposes. Launched in response to Japan's 5G project, SCP's major goal is to develop a broad base of machine intelligence technology as a means to increase national security and economic strength. (Arnold & Guy, 1986:40). VHSIC is also a programme to develop faster monolithic chips for military requirements. The DoD also formulated policies to encourage the semiconductor industry to research microelectronics, thereby reducing the amount of time needed to introduce new generations of chip technology into military systems (Arnold & Guy, 1986:40). The DoD also has large stakes in software initiatives. ADA programming language, for example, is part of a plan to unify the language in which military software is written. A special laboratory, the DoD's Software Engineering Institute, was established as some 90% of the cost in embedded systems currently being developed for the DoD lies in software (Arnold & Guy, 1986:44). The last major programme, and by far the most publicized, is SDI, also known as "Star Wars". Planned to last five years, the plan has received US$ 26 billion in financial resources to develop a space based system to defend the United States against enemies' inter-continental ballistic missiles (ICBMs). To carry out these expensive projects, the DoD has the largest budget of any government department in the world. According to Arnold and Guy the American government spent US$7.75 billion in 1984 and US$9.5 billion

in 1985 in their weapon programmes, divided between both applied and basic research (Arnold & Guy, 1986:44). This demonstrates the extent of state commitment to industrial development related to broader strategic interests.

In the civil sector, on the other hand, where there is really no coordinated effort, firms are left to structure themselves according to on going market forces. This is where American views of the 'hands off' approach becomes most visible. However, with such an extensive influence in defence related activities, it is very difficult for the civil sector not to be influenced by military concerns, and state regulation.

The civil industry benefits from activities in the defence sector in many ways. Trained engineers and technicians are often encouraged to move from government supported defence work to the private sector and vice versa. For example, the founders of Hewlett Packard (HP) started in the defence sector where they were employed by General Electric (GE). They left GE to form HP, a commercial enterprise that also depended on defence contracts during its formative years (English & Watson Brown, 1985:70). Also engineers take with them ideas and solutions first developed for military purposes and make them commercially viable. Most American leading edge technology research is undertaken at the country's top universities such as MIT, Stanford, Berkeley, Harvard, etc. These schools are civil environments catering to a great extent to military demands, and in a way are tied to them as most of the projects are funded by the DoD.

The private sector is also a heavy investor in R&D. The best example is IBM. In 1984, IBM's R&D budget totalled US$3.15 billion, over 7% of its total computer revenue for that year. Other firms like HP, DEC and ITT spent over US$ 500 million p.a. on similar activities (Hewitt, 1988:25).

The first phase of American electronics from the early 1940s to the 1960s was characterized by the formation of large electronic conglomerates with business interests well established outside national boundaries. By late 1950s the US had a well developed informatics industry. American informatics producers supplied over 70% of the world's market for computer systems (Piragibe, 1986:32). Industrial spin offs were used both in the private and civil sectors. The importance attached to the defence-industrial complex secured the necessary resources to finance, coordinate and undertake substantial R&D activities. The national government provided a guaranteed market for American products through the Buy American Act and other forms of subsidies (English & Watson Brown, 1985:76). These subsidies helped to cover initial overhead costs such as R&D,

product and process development, and favoured the absorption of necessary learning and scale economies and consequent price reduction.

Challenges to the American informatics industry, already mentioned above, were not only external to the country. In the mid 1980s, despite all the resources that were made available to develop basic and applied research, the industry faced some internal problems. In the sphere of human resources, a shortage of faculty and doctoral students put at risk the American tradition of basic research and leading edge scientific discoveries. Also computer engineering facilities in American's leading research centres were considered already obsolete through the rapid pace of technological change (English & Watson Brown, 1985:75). These factors led some to argue that American industry was no longer competitive and flexible enough to accommodate to changing patterns of international competitiveness in this particular industrial sector. It was also agreed that to remain viable the US electronics industry would have to be restructured.

In sum, the American experience reveals a tight link between defence interests and the development of electronics industry through liberal/hands off policies. Developments in military related R&D have led to most of today's civil applications of products and materials and have determined research and development trends in the American industry. American corporations still retainan *important* position in the world industry, partly because of their existing strength, structure, level of internationalization, technological know-how and, last but not least, because of the amount of financial resources they dedicate to R&D activities. But in spite of these strengths, the challenge to the American electronics industry by the Japanese has led to questions about the government policies towards the industry, and necessitated a restructuring of strategies.

Japan, on the contrary, has exercised a more direct 'hands on' approach to manipulating national strengths and weakness to secure a very strong hold in world markets and to try to consolidate its model of economic growth in the world. The Japanese case is examined below.

2.3.2 - The Japanese Model - 1980 -?

Economic and technological policies have been part of Japan's development strategies for over a century; and the idea that the state has a legitimate role to play in development is also well accepted (Arnold & Guy, 1986:70).

In the 1950s post-war period, Japan found itself in a state of dependency on

imports and local markets dominated by American TNCs. The alternatives to foster local indigenous development were:

a) Labour intensive types of industries for a country with a large population, few resources and little capital savings,

b) or the development of a capital and technology intensive industrial structure (Arnold & Guy, 1986:71).

The choice was for an active technology policy. This aimed to protect Japanese firms which were in a weak bargaining position vis-a-vis foreign companies. Later, these policies aimed to dismantle protectionist policies so as to encourage Japanese firms to compete internationally. The protectionist phase lasted almost two decades leading to the expansion of national groups, giving them the assurance of a captive internal market; and improving their competitive position internationally.

Central to Japan's dynamic and effective approach to economic and industrial development is the agency in charge of the coordination of policy, MITI *(Ministry of International Trade and Industry)*. MITI does more than just provide general and broad industrial policy. It is set up so as to cater for the specific needs of the electronics industry. State bureaucrats are in constant contact with industry, and they are familiar with and responsive to industry's needs. (Arnold & Guy, 1986:77).

The first batch of state support measures consisted of restrictions on foreign through limiting foreign direct investment (the law concerning foreign direct investment of 1950), suspending joint ventures (the foreign exchange control law of 1949), and restricting purchase preference to Japanese goods which was administered by JECC *(Japan Electronic Computer Company)* in charge of purchasing domestic products and leasing them to the market.

Technology acquisition remained the crucial issue in the country's strategy. The government set up national R&D laboratories associated with MITI *(Electro-technical Laboratory)*, and with MPT *(Ministry of Post and Telecommunications)*, the NTT *(Nippon Telephone and Telegraphy)* R&D centres. The close relationship between the three agencies facilitates the acquisition of technologies and the execution of programmes. According to Arnold & Guy, Japan is one of the few countries that has been successful in adopting an infant industry policy (Arnold & Guy, 1986:83).

Today there is no formal protection of the domestic markets. However, Japanese companies are very successful in export markets. They have led Japan's economic

recovery and today lead the country's growth. Export activities make Japanese firms very competitive domestically. This high level of competition works as a barrier to potential foreign entrants that must be equally able to compete in the Japanese markets.

Government expenditure on R&D is not very significant in Japan. Since the war, defence related activities including defence R&D have been restricted to 1% of the national GNP. This constraint has affected Japanese's economic strategy. To oppose concrete limits on how much is invested, Japan has historically given importance to other factors. For example, Japan produces 40% more graduate engineers than the US. To train them properly the country supports academic activities and together with industry provides the universities with funds for research. MITI's bureaucratic industrial structure, on the other hand, encourages the relationship between university and industry on applied research. These strategies have included different forms of technology appropriation such as technological transfer, reverse engineering and manufacturing licensing.

In the first years of Japanese industrial policy, in the 1960s, MITI itself took the responsibility of negotiating directly with IBM on patent licensing for Japanese firms. Ten years later MITI allowed greater technology transfer agreements between Japanese and other European and American firms, while it also made available results obtained from the governments R&D labs (Piragibe, 1986:70). Once some benefit was extracted from these arrangements, the country changed its strategy. In the late 1960s and early 1970s Japan became a reputable OEM producer to take advantage of this effective form of subcontracting.

OEM producers make equipment which is not sold to the final consumer but to other producers who incorporate the parts into their own systems and then market them with their own brand name. This arrangement allows for a degree of specialization to be achieved as the producer is not obliged to learn and specialize in the entire process of production of a complete system. As a supplier the firm receives from the subcontractor the necessary technological and technical support to achieve the quality and price ratio desired, while obtaining the necessary learning and scale economies for that particular component. Fujitsu started out as an OEM producer of large mainframe computers for Amdahl, Siemens and ICL; peripherals to Memorex, and robots to General Numerics. The American firms DEC and Control Data have also been very well known OEM producers (Delapierre & Zimmermann, 1986:21).

enables these firms to underwrite otherwise very expensive R&D and new product development costs. They are the pillars of the Japanese economy.

Japanese firms and Japanese policies, however, have always been turned inward. In 1985 national companies carried on 80% of their business inside Japan (Delapierre & Zimmermann, 1986:51). And even so most of the transactions were carried out in the realm of consumer electronics and semiconductors rather than informatics commodities *per se*. The Japanese experience shows that under certain conditions (a highly favourable domestic environment for production and high value, low weight, mass produced goods) an export strategy may be superior to one based on foreign direct investment (hereafter FDI) (Morgan & Sayer, 1988). This also means that a lack of FDI, one of the pillars of the NIDL thesis, is not to be seen as evidence of backwardness as other strategies have proved to be as powerful in securing capital expansion.

Strategies used by the Japanese government to extend the influence of Japanese corporations outside Japan were initially targeted to developing countries' markets rather than to American and European markets. Japan linked its foreign aid programme to developing countries to commercial interests of Japanese firms, offering soft loans to underwrite the purchase of Japanese goods. Japanese influence is quite pronounced in the Pacific rim region (recipient of 75% of total Japanese commercially tied aid), followed by Africa, the Middle East and Latin America.

The choice to focus on the Pacific Basin has a strategic significance. Japan has a leading edge on the command of non-roman scripts of local languages and a deeper understanding of local culture, features which are yet too 'foreign' to many Westerners. Its leadership in the area is based on the control and development of technologies that can process information in those languages. Also IBM has a rather weak participation in the region (English & Watson Brown, 1985). This cultural and economic affinity is strategically beneficial to the formation, under Japan's leadership, of a regional Pacific block.

Most recently it is clear that there has been a change in strategies that would underpin the technological leadership so far achieved rather than concentrate on structural development. The Fifth Generation Computer Project is an example, which inspired reactions from both the United States (The Star Wars programme) and Europe (the ESPRIT and Eureka programmes).

With the advent of a capitalist crisis of world proportions in the late 1970s and early 1980s, described above, Japan has also become more aggressive in its internationalization schemes to include industrial investments in the AICs as a means of pre-emptying protective barriers and minimizing battles in the GATT over trading practices (English & Watson Brown, 1985). There is still great interest in OEM exports as a means of increasing market shares and exploring new markets. Japanese internationalization strategies also include setting up new production facilities within major competitor's markets (USA and Europe), as a means of circumventing protective barriers, and to gain access to new markets. This strategy also involves the reduction of export activity and an intensification of activities directed towards international standardization and co-operation in R&D.

These aims were spelled out in MITI's *Visions for the 1980s* and,

> "stressed Japan's need to reduce dependence on external energy sources and for basic research to underpin new industry. It identified five problems for Japan: an ageing society; lack of renewable resources; employment and human worth; primary and tertiary sector productivity; and integration into the international community. Knowledge based industry was seen as necessary to cope with these problems "(Arnold & Guy, 1986:75-76).

In sum, Japan's success rests on its explicit approach to economic and industrial development which specifies targets for the Japanese industry, the training of Japanese labour, and the emphasis, notably from the mid 1980s to the present, on staying technologically ahead. The results of this determination are reflected in the growing importance of the Pacific Rim geo-economic and political region under the economic influence of Japan. The country enjoys an unparalleled period of prosperity and strength. To some, Japanese success alone explains much reshuffling of international political and economic scenarios and inter- and intra-regional relations.

2.3.3 European Approaches to Industrial Development

The issue of the technological gap between American and European TNCs gained momentum in the 1970s [1]. Europe recognized that America's effort in R&D, product development and innovation in the area of electronics were gradually differentiating the American economic profile and the strength of the country vis-a-vis Europeans. The 1970s were also characterized by a deepening of efforts towards internationalization of

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[1] See EEC publications listed in the bibliography EEC 1979, 1980a, 1980b, 1982, 1984, 1985, 1987.

American firms in Europe, and their eventual control of local markets. The process of internationalization of American firms into Europe compelled European national governments to exert greater intervention in their indigenous industries (Baudin, 1987; Webber et al., 1986).

National responses to American and most recently Japanese efforts to control the world production and markets of informatics goods vary enormously from country to country. Yet Europe, neither as a region nor individually (the region's nation states), had the expertise in a wide range of technologies within the electronics complex, nor an internal market large enough to serve as a launching pad for European products and FDI (English & Watson Brown, 1985:81).

Not all European countries have local informatics industries. France and UK are medium sized entrants in the electronics and information technology race. Their economic resources are not sufficient to allow them to compete with countries like Japan and the United States; and yet not small enough to prevent them from developing their domestic industries.

In terms of their developmental approach, the United Kingdom has chosen the liberal free market strategy (Kelly, 1987). France relies on a centralist policy and on direct state intervention (Arnold & Guy, 1986:131). France and the UK are also very heavy investors in the development of military industrial complexes. In 1980, the USA, France and the UK spent 47%, 40% and 60% respectively of their government R&D funds on defence alone. Defence and aerospace together consumed even greater figures (64%, 49% and 65% by each of the mentioned countries) (Arnold & Guy, 1986:12). Other European countries are the home of very successful corporations in other branches of the electronics complex such as the Netherlands and Sweden and Italy (e.g., Phillips, Ericsson, Olivetti), while others are heavily dependent on imports (Portugal and Greece) or act as suppliers of parts and components for leading TNCs (Spain).

European based informatics industries have never had a significant role in the sector's international division of labour. Trade and employment figures show the flow of commodities within the regions, emphasizing the importance of regionally based TNCs in maintaining spatial monopolies inside their home countries, and the region occupies a secondary position in the international informatics complex. The following section briefly examines two European cases of France and the UK, and looks at the European wide experience, under the umbrella of the EEC, to illustrate recent European

responses to both American and Japanese industrial strategies.

a. France

France's decision to invest in the development of a national electronics industry came partly as response to the increasing expansion overseas of US interests from the mid 1960s onward. Two factors determined government intervention in the process of economic development in this sector. First of all was the take over of *Compagnie des Machines Bull* by the American General Electric in 1964 (Delapierre & Zimmermann, 1986). Bull was France's national informatics firm. The second factor was US imposed restrictions on the sale of large mainframes to France's Nuclear Commission Agency. These two underscored American superiority in the sector and the consequent growing French dependency on American products and willingness to sell these commodities.

Like Japan, France has had a long tradition of centralism in industrial policy (Piragibe, 1986). The nationalistic and interventionist nature of the country's electronic policy is no exception to this. In 1966 was created the *Plan Calcul*, whose target was to boost computer production by providing and combining the necessary financial, scientific, technical and human resources. The Plan was institutionally coordinated by a *Delegue a L'Informatique* which, in turn, was aided by the *Commission Permanente de L'Electronique du Plan* (COPEP) and the *Comite de Recherche in Informatique* (CRI). The Thompson Group, a major leading French conglomerate coordinated the industrial side of the programme. The Plan was scheduled to last five years (from 1966 to 1970) with an operating cost of F726 m. (US$150 m.). A company CII - *Compagnie Internationale pour l'Informatique* was formed in 1966 to engage in computer production, and two thirds of *Plan Calcul* 's resources (F 480 m.) were allocated for that. The government adopted a Buy French Policy and sponsored two other companies SPERAC *(Systemes et Peripheriques Associes aux Calculateurs)* responsible for the production of peripherals; and SESCOSEM in electronic components. Software development was centralized on the hands of IRIA *(Institut des Reserches d'Informatique et d'Automation)* (English & Watson Brown, 1985:98).

During the 1970s further alliances between government and companies were set up. The failure of the first European collaborative task, the UNIDATA project, meant stronger partnerships between CII and Honeywell which culminated with a joint venture between CII - Honeywell and Bull where Honeywell supplied the technology for the production of larger machines. The government also developed other sectorally define

development plans: the *Plan Mini-informatique* (for minicomputers), the *Plan Peri-informatique* (for peripherals) and many updated versions of *Plans Calculs*. Semiconductors were looked after in the *Mission pour les Circuits Integres* with the *Plan Composants*. The strategy included among other things the association of American and French companies to obtain from the former the necessary know-how for the production of these vital components (Baudin, 1987).

France, of all European nations, went furthest into centralized planning to develop a national capacity in all branches of the electronics complex. Electronic sectors were identified as parts of *filieres*. The idea was built around the notion that all industry can be divided into a number of *filieres*. Each *filiere* represents a chain of supplier-user relationships from primary goods to consumption (Arnold & Guy, 1986:132). As a result any measure to change a link within the *filiere* can have an impact on the others.

The *filiere electronique* is looked after under the *Plan d'Action pour la Filiere Electronique* and has US$ 20 bn. in resources for the first five years. It is an ambitious plan. It selected four companies to lead the development programmes in four strategic areas: CII- Bull is in charge of computer production. Alcatel is in automated systems and office automation, Thompson is in charge of consumer electronics and Matra is in charge of the production of components. The goal is to make France the third leading producer of electronics after Japan and the United States (English & Watson Brown, 1985:100). This ambition, however, comes together with a number of side effects. The two most obvious ones are scale and R&D capacity. France lacks in both. National market bottlenecks and lack of financial resources to fund stand-alone projects contribute to the problem of the technological gap. In order to catch up and compete with both Japan and the USA, France may have to consider moving towards greater collaboration and cooperation at the level of the firm within many of the existing European collaboration schemes.

b. United Kingdom

Great Britain's leading company in the informatics sector was ICL. Created in 1968 under the Wilson Labour Government in the Industrial Expansion Act, it was part of an industrial rationalization programme to create a large internationally competitive presence in the computer industry (Kelly, 1987:41). The company came into being after a series of mergers and acquisitions as part of a capital concentration strategy to oppose IBM's hegemonic position in the field. ICL was also protected by government

preference purchases so that in 1974 it controlled 46.5% of the local market (Piragibe, 1986:18)

The UK, in contrast to France, has opted for a more decentralized liberal industrial policy which is heavily backed by the country's Conservative government. For over 20 years the government has supported a policy of decentralization in Britain and the pattern became particularly popular in the recession of the early 1980s.

Defence receives the greatest support in British government priorities as well as consuming the largest shares of government R&D funds (60% spent on defence). Defence related research is not as easily absorbed by civil spheres, as in the US context. Projects are very expensive and complex, and are supported through government procurement policies.

The United Kingdom has no centralizing agency to coordinate the country's R&D activities. Institutional support and coordination of policy has been fragmented between many agencies. The Ministry of Defence (MoD) controls development in defence electronics, the Post Office (PO) and British Telecom (BT) are in charge of telecommunications, while the Department of Trade and Industry (DTI) deals with informatics production and final end users. At the same time during the 1970s the MoD, PO and BT have adopted a type of protective policy which shelters the large UK firms from direct international competition. During the 1980s, under the Conservative government, non-interventionist strategies and spending cuts have exposed national firms to greater risk. This transition from protection to liberalization has not strengthened the British position in the global industry. Like other European companies and sectors, the British computer industry experienced a decline in both output and employment. The emphasis on defence and telecommunications has also meant that other sectors could be and in fact are controlled by multinationals. IBM UK, Hewlett Packard, Texas and NEC account for a sizeable proportion of output and other microelectronic firms control the semiconductor sectors (Morgan & Sayer, 1988).

There are visible problems with the British liberal approach. The British electronics industry suggests that over decentralization - along with a lack of product focus and excessive reliance on defence - is doing serious harm to the global competitiveness of leading national companies such as GEC, Ferranti, Plessey and Racal. The structure of the local computer industry remains faithful to a late 1960s and early 1970s idea of focus on short term results rather than long term investments

(Financial Times, 01/07/88).

2.3.4 Summary

To summarize, the discussion of the two countries above demonstrates the crucial role of the state in preserving national interests, resources and strategies, and the multiplicity of options available to countries to do that. Constrained by small markets and limited in financial, human and technical resources for more advanced R&D activities, Europe stands a weaker chance of winning the technological race, and of maintaining as individual national states a position in the international division of labour. It has been noted:

> " France and the UK are in the gap of a logic which states that whichever route one takes, the end point is always the same. All roads do not necessarily lead to Mecca.... The two countries have faced similar challenges and responded to them differently "(Arnold & Guy, 1986: 178).

As to Europe as a whole, the EEC option has turned into some kind of solution or alternative to a battle lost before it even began. To others, it is another sphere where national resources can be invested in the community. The case of informatics in the EEC is examined in section 2.5.1 below.

Changing patterns of internationalization from the 1950s onward have given rise to three industrial development regimes in informatics under the leadership of the United States from the 1960s to the late 1980s, Japan in the 1990s, and a more inward oriented model of Europe from the mid 1980s on.

The task of developing technologically autonomous national industries is by no means simple. As illustrated above, a country's choice of development strategy may vary enormously and it changes with time. By and large, the United States and Japan have maintained a coherent approach to the development of their respective industries. In the US case this has been based on a liberal development focus of an industrial military complex where the country has managed to keep a lead in technological development and output, even though production is no longer as cheap and productive. In the Japanese case, it is based on a centralized and target oriented policy to include a broad range of interdependent sectors. Japanese firms have started out as a mere assemblers of parts and components, to become efficient reverse engineers, OEM subcontractors and world wide industrial competitors. Europe, in turn, stands on the edge. Individual nations have realized some of the financial and market shortcomings of operating alone.

Under the umbrella of the European Community, they hope to gain a better chance to protect European TNCs, and to maintain a place in the technological race.

As stated in the beginning of this chapter, technological change and capital internationalization have had an impact on labour markets in informatics and on the technical and spatial organization of this industry worldwide. The next two sections move from a macro economic and political focus on the industry to examine uneven patterns of development. The impact of technological change and new forms of capital internationalization on labour is examined (section 2.4), and the ways developed countries cope with uneven development is reviewed (section 2.5). This discussion takes into account the changes in the world's political economy described above (section 2.2) and examines contemporary strategies that are emerging.

2.4 Technological Change, New Forms of Capital Internationalization and the Labour Market

In the review of uneven development in Chapter one, I demonstrate following Smith that the movement of capital between sectors and sub-sectors of the economy creates spatial unevenness. Technological change and shifts in capital internationalization strategies, both determinants of industrial development, have a direct effect on labour and employment. These changes have been the object of study in the specialized literature (Cho, 1985; Ernst, 1985; Elson & Pearson, 1981; Fröbel, *et al,* 1980; Hewitt, 1988; Kaplinsky, 1987; Sayer, 1988; Scott, 1987).

The purpose of this section is to illustrate patterns of uneven development within the AICs. The technological developments from the 1950s to the present described in section 2.2 above, have deepened social and technical divisions of labour, calling for more diversified labour skills and workers to execute new functions created by new technical demands. These in turn, are spatially divided according to different social and technological endowments of regions and countries.

Capital internationalization strategies of the past 30 years have included the relocation of parts of the production process (e.g., assembly), the establishment of factories in the Third World and, to a lesser extent, the setting up of joint venture agreements with local producers. According to the NIDL thesis the relocation of assembly facilities has been linked to cost reduction. Setting up new factories offshore helped pre-empt protective barriers and to exploit local and regional markets.

In what follows, I examine how informatics employment in the AICs have changed quantitatively (number of people employed in the industry); qualitative (changes in labour composition and organization) and geographically. Data and processes pertaining to employment changes in the NICs will be dealt with in Chapter three (section 3.5).

Hewitt has identified three basic trends affecting employment during the course of industrial development of informatics industries in the OECD countries. First, industrial expansion in the 1960s has been followed by an overall *increase in jobs*. Second, changes in products and processes followed by productivity gains have often caused *job decline and stagnation*. Thirdly, international competition has resulted in *shifts in employment* across countries and sectors (Hewitt, 1988:38).

Trend 1 - Job increase. The first phase in the computer industry is characterized by a continuous growth in electronics employment across OECD countries. Data comparisons are very difficult to establish given distinct ways of defining and measuring employment. In the United States there were 217,000 jobs in the computers and peripherals sectors in 1974 and 385,000 in 1980. In the UK, employment figures were 68,401 and 75,825 for the same sectors and same years (Hewitt, 1988: 39).

Qualitatively, the types of and demand for labour at the beginning of the computer industry are associated with R&D activities, systems development, software production and support interactive services to very specialized customers. The first large systems (e.g., Eniac, Univac I, IBM 7090) of generations one and two (see table 1.1 in the Introduction) were few in numbers and almost custom made to fit specialized functions. The lack of an assembly line to speak of, and of the necessary scale to achieve standardization, perpetuated the importance of skill in the sector. The technical division of labour was restricted to conceptualization and almost batch production, where most of the work put into their production was geared to putting a system together, piece by piece, the search for solutions rather than the assembly of standardized parts.

In the late 1970s came the turn of smaller machines. They were the minis, micros, printers, disk drives and an array of other support equipment to make computers operational. The scale of these product innovations, the product range, the expansion of markets, and the increased demand for mass produced computers (scientific or custom made products) were reflected in labour composition, and in the geographical expansion of computer markets and computer industries. New products

brought a deepening of the technical division of labour in the industry. The growing demand for these products called for greater standardization of the production process into assembly lines, and these demanded less skilled assembly workers (Morgan & Sayer, 1988:108).

According to Smith, changes in the technical division of labour do not necessarily have a significant spatial impact, they are carried out inside the work place and these create different forms of social organization (Chapter one, section 1.5). Thus, the spatial requirements of this period of increase in jobs were geographically restricted to the US and American firms. Industry had to be located where research and development could be done, and of course, where engineers and specialists work and live. Computer firms were concentrated in and around more traditional industrial areas of Eastern USA, encircled by the bulk and specificity of their products and markets. At the same time, firms like IBM and Burroughs had already expanded their commercial activitie and factories to locations outside the USA (Bakis: 1977).

A deepening of technical (new processes) and social (new products) divisions of labour in the industry, followed by a growing strategic importance of informatics and its functions prompted governments to promote national industries, as happened in Europe. New processes and products lead to the possibility of separating the productive process into various stages of production and therefore, different production sites. This revolutionized the industry's spatial patterns. Companies (mainly American) were free to move part of their operations to areas where the tasks could be performed most efficiently. The partial relocation from the US to foreign countries was viable. Starting with the American firms, off-shoring became a widespread practice among semiconductor firms from the mid 1960s onward, and for computer producers 10 years later. These spatial changes characterized the second phase, that of job loss and stagnation.

Trend 2 - Job decline, stagnation. The impact of technological change leading to new products and new processes in OECD based informatics industries was associated with job stagnation and or loss. Again using OECD statistical data on electronics employment, the US and most of Europe, suffered some form of employment stagnation and or loss. West Germany lost 30,000 jobs from 1974 to 1984 (Morgan & Sayer, 1988:108). In the UK employment in the computer and peripherals sector fell from 68,401 to 66,865 between 1978 and 1983. Looking at total UK electronics

employment, there was a loss of 64,391 jobs between the same years (Hewitt, 1988). Leading industrial firms also experienced similar processes. With new technologies and processes, production no longer had to be done all under the same roof. At the same time, higher production scales and the standardization of tasks demanded more workers to be involved in assembly activities (UNCTC, 1986). Increasing labour demands inside the AICs (e.g., higher wage levels, better working conditions, higher productivity) made employment inside the AICs for assembly activities very problematic.

Trend 3 - Shifts in employment. This phase comprised, in fact, two inter-related processes. First there was a surge of *new labour markets* associated with new employment demands resulting in the job increases of the first trend (UNCTC, 1986). These demands varied between the AICs and the NICs. In the AICs case, there was a growing demand for people to work in sales, maintenance, support, system support, software, and naturally R&D, in some ways like the first phase. In the second case, the NICs, the demand was by and large for a particular type of assembly worker. These consist mainly of young, single, 'docile' and 'disciplined' females who could perform the tasks necessary for the tedious and disciplined assembly work (Hewitt, 1988). Spatial requirements in the AICs to satisfy changing labour demands were associated with a surge in investments in the most developed AICs countries, that is in the USA (e.g., Silicon Valley and Route 28) and less so in Japan. It was also characterized by growing investments in the less industrially advanced AICs, in places like Scotland, Ireland, Spain, Portugal (Financial Times, 14/11/89). In 1988, over 72% of Scotland's electronics output was produced by US based TNCs and a mere 12% of the inputs were sourced from within Scotland itself (Financial Times, 07/06/90). Data on these job creations are given in Chapter three below.

The second aspect of the phase was characterized by a change in *labour demands* and markets both inside the AICs and NICs. In the AICs, profit objectives and related technological innovations were not exclusively aimed at improving products, but included a number of solutions directed towards rationalizing and intensifying production processes. During the last few years, new competitive behaviour of firms suggests that companies are finding within the AICs most of the elements that permit them to maintain their capital objectives and still enlarge their markets and raise their profits. In the AICs, this trend is manifested by the introduction of automation, flexibility, just in time production facilities, economies of scope, etc. It also involves

changes in employment composition. Between 1986 and 1988 IBM laid off 16,000 workers and redeployed 21,000 others from purely administrative functions to higher skilled production and customer relations (Financial Times, 07/06/88). There is a wave of technological change paralleled by a phase of capital mobility starting in the late 1970s and characterized by the return of certain portions of the productive process back to the AICs.

In sum, technological change and profit squeezes have had an impact on the quantity and quality of employment both inside the AICs and the NICs. Using Hewitt's three trend model, employment quantum and quality suggest that AICs electronic employment has gone through 1) *job increase*, represented first by a demand for high skilled engineers, and second, after standardization, for a rising demand for assembly workers; 2) *job decline and stagnation* in the AICs specially among lower skilled workers as a result of the partial relocation of production to other parts of the world; 3) *shifts in employment* comprising first the creation of new jobs in the NICs and second, the transformation of labour demands and markets both in the AICs and NICs. In the AICs, there has been a trend towards automation of production processes in plants, and for the utilization of a particular types of workers to do the work (Cho, 1985). In the NICs, there have been improvements in the skill levels, as has been demonstrated for the case of Brazil (Hewitt, 1988) and for a selected group of East Asian countries (Henderson, 1989).

In general terms these trends have at least two points in common. First, the consolidation of a divide between conception and production predominant in the second phase has enhanced the rigidities of the labour force at both extremes of skill level, and has emphasized the inflexibility and/or centrality of the labour force against the idea of a highly mobile labour. As has been argued in Chapter one, not only are companies restricted to where they could relocate part of their productive activities (taking into account the specificities of the labour force required to perform such tasks, and the concern over a whole set of externalities associated with political stability and national government support against possible unionization movements), but they also face constraints over where to locate R&D centres, and even market outlets. Front end activities (e.g., R&D, management, marketing) are readily available predominantly in the most developed industrial areas of the United States, Japan and selected European countries, where one also finds well endowed research centres, complementary policies

and funds to carry out R&D work and pay the increasingly higher wages demanded by top scientists.

Secondly, and equally crucial, the split of the labour process between conceptualization and production indicates that the crucial *social component of technological development remains in the developed nations.* Parts of an already fragmented production process are transferred to developing countries. The new industries find it difficult to learn and absorb the technological process, and they lack top quality training centres and universities to produce future scientists. Table 2.1 describes the nature of the IDL in informatics by identifying the types of activities developed by leading TNCs in countries other than their own. Although R&D activities tend to be concentrated in the AICs and assembly in the NICs, some Latin American and East Asian countries have succeeded in getting something more than another branch plant located in their national territories. Along these lines, it will be shown in Chapter three that some developing countries have managed to acquire some productive expertise in informatics, and within the group of the NICs these countries distinguish themselves as indigenous producers of informatics goods and not simply assembly sites for these goods.

The table also demonstrates the extent of internationalization of manufacturing plants throughout the Third World. American firms have a pattern of internationalization that is quite pronounced, to a lesser extent so do European and Japanese competitors. In Western Europe ten of the firms indicated have assembly activities inside the region and three others are European based (indicated by m). Asia comes second with seven TNCs branch plants followed by Latin America with six. This list is not comprehensive and reflects 1986 data for computer production only. Since then companies have already restructured their geographical positions.

Table 2.1
International Division of Labour in Informatics Production
Selected Companies and Locations

Geo. Location	*USA*	*Europe*	*Japan*	*Latin America*	*Middle East*	*Asia*	*Other*
IBM	X	@#m	@#m	@#m	Om	O#m	@#m
DEC	X	@m	-	@	-	-	-
Burroughs	X	@#m	-	m	-	#m	m
NCR	-	X	#m	-	-	m	-
Sperry	X	m	@#m	m	-	m	-
H Packard	X	@#m	-	m	m	-	m
Fujitsu	m	m	X	-	-	-	-
ICL	@#m	X	-	-	m	-	@#m
Olivetti	@#m	X	-	m	-	@#m	-
Wang	X	m	-	m	-	m	m
NEC	-	@#m	X	-	-	-	-
Xerox	X	m	-	-	-	-	-
Nixdorf	@#m	X#m	-	@	-	-	-
Data General	X	-	-	-	-	m	-

© - Research & Development m - Manufacturing X - Home base
\# - Software Develop, System analysis Ø - Local Adaptation of product
Source: CEREM in Delapierre & Zimmermann (1986:56)

This section illustrated the uneven development within the AICs. These unevenness is expressed both in the type and quantity of labour required and involved in the labour process as well as the spatial configuration of informatics in the AICs. The next section discusses one strategy to cope with uneven development, industrial collaboration.

2.5 An AICs Perspective on Uneven Development

This chapter first outlined the main features of Fordism in the 1980s, and then described the possibilities for and constraints faced by AICs' governments in formulating policy and shaping industrial development in accord with national priorities. One of the constraints faced by governments derives from the resources required to undertake their ambitions. These include not only the ownership of leading edge

technology but of all financial, technical and human resources to develop it.

The industry's features, together with a growing technological convergence have a crucial bearing on the need to internationalize production. These present technical and economic pressures are not governed by strict market or economic forces. They symbolize the coalition of economic and political forces together over determined and selected world regions.

The market expansion strategies of leading firms in AICs varied greatly according to particularities of different sectors, products, policies and so on.

Capital internationalization is very evident in the informatics industry through the operations of TNCs. Dependency theorists, in turn, have focused on the commercial expansion of capital through trade. The NIDL theorists have linked the internationalization of productive capital with labour cost saving strategies. Smith explains capital internationalization as part of a profit cycle where capital moves across and between sectors to overcome declining rates of profit and constraints on accumulation. In addition to these justifications capital internationalization can occur as a result of:

1. Technological convergence
2. Shrinking product life cycles
3. Overriding R&D costs
4. Smallness of individual national markets

To overcome these constraints on growth characteristic of the informatics and other electronics industries companies and governments are seeking alternative solutions. One which deserves particular attention is industrial collaboration both at a national and international level and aiming at achieving greater control of R&D production and market aspects of this highly competitive global industry.

International industrial collaboration amongst different partners is one option available to industrialists to overcome falling rates of profit. The driving force behind all these patterns of internationalization is capital accumulation, not technological change and diffusion on its own, and major companies cannot expect to survive and continue to accumulate capital while remaining within the confines of even large domestic markets. International collaboration as a new form of internationalization is here defined as *an emerging form of capital organization to optimize production activities where different national capitals join together efforts to produce commodities.* Their

partnership is nevertheless based on industrial capacity and mastering of specific techniques rather than on labour costs (Financial Times, 23/05/87). The following section examines the main features of international collaboration.

Industrial collaboration experiences are primarily focused on R&D activities among different companies, companies and research centres and amongst different countries. Spatially these collaboration schemes are, in contrast to setting up assembly lines at cheap labour cost sites, largely confined to the AICs. These partnerships amongst leading firms and leading economies, reflect a degree of centralization and concentration in the industry in the AICs.

Second, there is a critical and yet unclear boundary between pre-competitive and market oriented research. Current R&D programmes restrict themselves to the first type of investigation often to avoid the complications amongst project participants regarding the ownership of technology, the implications of the potential strategic value of discoveries, and the right of industrial patents.

Third, partnerships are usually established on the basis of similar capabilities between members in expertise, size, technical, technological and human skill capacity, and R&D budgets are often designed on a shared costs basis (EEC, 1985).

Fourth, programmes are deeply tied to some form of governmental institutional structure. Those bureaucratic structures tend to be quite rigid and cumbersome. Decision making is diffused through a complex institutional web of public laws and regulations that if not well coordinated, can compromise the success of entire projects. State intervention can be in the form of active participation in the R&D programme as a financier, supervisor or active participant.

Fifth, programmes are opened to industrial participants as much as to universities and other research bodies as a means of reducing the institutional gap between the two.

Sixth, international cooperation is a way to overcome the smallness of local markets (as is the case in Europe) and to overcome export restrictions on potentially new foreign markets (which is now very clear with the efforts of American and Japanese based TNCs to become partners in European inspired cooperation programmes).

Lastly, the new forms of industrial-state cooperation place a lesser importance --or even none-- on the search for exploitable low wage labour power as a means to increase profits. In contrast to other forms of capital flight which rely on low skilled and cheap workers, the type of labour involved in R&D programmes is of a highly

skilled and highly priced nature.

Of the three regimes of industrial development reviewed here in this chapter, the European Commission experience with industrial collaboration is the most developed and complex. The following section reviews the European industrial development strategy based on different forms of national and regional industrial collaboration. This strategy is one way to cope with Japanese and American technological and market attacks on Europe.

2.5.1 The European Economic Community

The EEC, created almost 35 years ago, comprises 12 nations and a regional population of some 335 million. Its participation in the international division of labour in informatics is very much restricted to isolated successes by national champions acting in their local and regional markets. The EEC national champions are: ICL (UK), Bull (France), Olivetti (Italy), Nixdorf and Siemens (West Germany) and Phillips (Netherlands).

Section 2.2 above suggested that European companies lacked the resources and capabilities to undertake programmes that could compete with Japanese and North American leaders on R&D expenditures. This problem is exacerbated by the highly competitive and segmented European market. To overcome problems associated with very small individual national markets, limited national budgets for science and technology, uneven and uncoordinated local industrial policies, and differing technical standards, European based companies opted to merge efforts into a single pool of financial, technical and scientific skills. In this sense European firms were the first in the world to foresee the necessity of and potential regional benefits of industrial collaboration and cooperation. [1] The reasons behind the cooperation option are reviewed below.

Industrial performance in the late 1970s showed that most European informatics firms were doing quite poorly. Over a 20 year period the exports of high technology from the Community fell from 190% to 110% (1983) (EEC, 1985:1). American based TNCs retained large chunks of the region's market for mainframes and related equipment. These circumstances prompted some forms of reaction from Brussels and

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[1] See literature on the European experience including EEC, 1979, 1980a, 1980b, 1982, 1984, 1985, 1987.

from the industry.

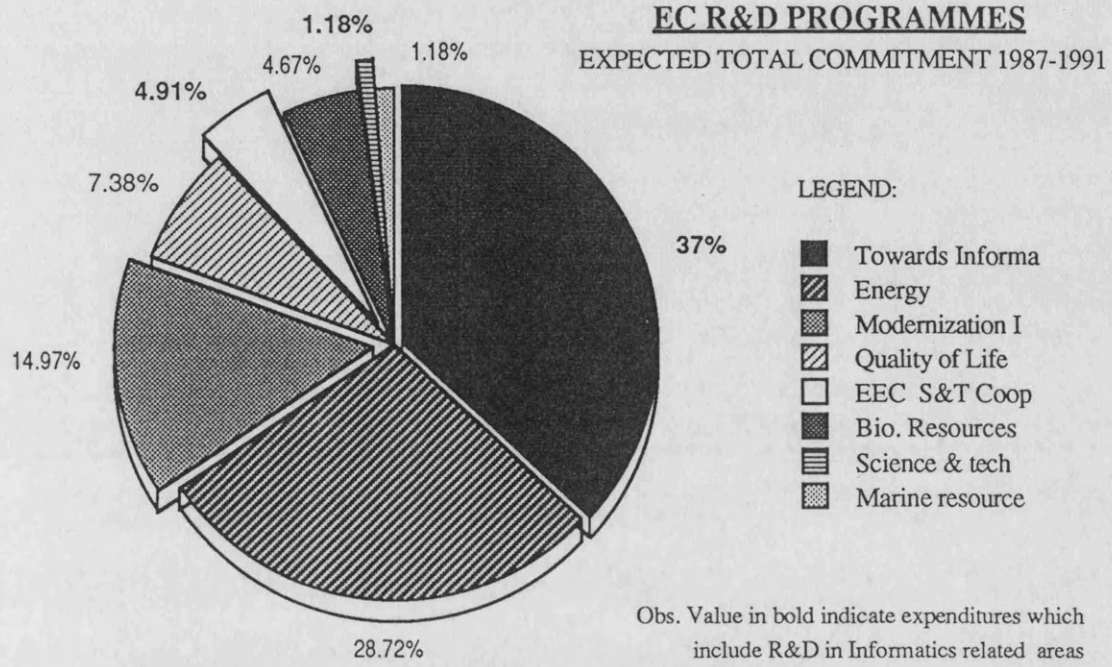
> "Europe launched the first two industrial revolutions: is it now missing out on the third? Can Europe be satisfied with its continuing domination in medium technology products when the newly industrializing countries of Asia and Latin America are ready to take over? Must Europe meekly accept the brain drain to the United States and let Japan take over its market shares?" (EEC, 1985:3)

Three motives inspired action: the un-competitiveness of the European informatics industry, the importance of economies of scale and the ensuing need for the European informatics industry to act together in innovative technologies without restraining intra-regional competition. However, being a supra state organization, the EEC has negative and positive points. Getting 12 member countries to cooperate effectively has not been easy considering differing industrial policies, different technical standards and nine major languages. Also the Community is subject to substantial limitations on how it can intervene in industrial policy. To get around these difficulties that EEC chose ways of achieving industrial objectives through regional development and industrialization programmes.

On the positive side, the community as a whole is a very large home market for European firms. The convergence of some of the leading economies yields the EEC producers an economic entity as big as Japan, able to compete face to face with American and Japanese leaders. Together, the region has a diversified technical and scientific capacity, a mature and widely developed industrial base, geographical proximity to all of its members, and the political will to engage in cooperation. The community has a number of multilateral projects to cover a wide range of the spectrum.

The leading EEC programme for industrial development is ESPRIT: European Strategic Programme of Research in Information Technology (EEC, 1987). Figure 2.3 below shows the distribution of resources amongst the various R&D programmes and the importance given to informatics which take up 58% of the total (UK, DTI, 1987).

Figure 2.3 EEC R&D Resources



Source: UK, DTI EC R&D Fact Sheet, 1987

The ESPRIT programme was created in 1984 to be the centrepiece of the European Community Technology Policy. Designed to make a contribution to the survival of the European informatics industry which was in danger of being crushed by American and Japanese competition, the programme also had a political function, to bring together different governments into cooperative research, and to spread the idea of trans-border collaboration and the development of leading edge technologies (Baudin, 1987). Today, after six years of its existence, it has a recognized success and serves as the model for both RACE (Research in Advanced Communications in Europe) and BRITE (Basic Research in Industrial Technology for Europe) R&D efforts in the related informatics fields (EEC, 1987; UK, 1987).

ESPRIT, planned to last 10 years, comprises R&D projects in five selected areas: microelectronics, software technology, advanced information processing (AIP), office systems (OS) and computer integrated manufacturing (CIM). This preoccupation with all sectors of the electronic complex or the *filiere electronique* that the French envisioned, predominates in the experience of all the European industrial and research consortia. All the research must be done at the so called pre-competitive level. This has facilitated the design of very specific and clear rules of participation and evaluation of proposals. It also helps the overcoming of barriers in pre-market projects development.

In terms of budget, the first programme phase, from 1984 to 1988, received a total of ECU 1500 m., 50% of which ECU 750 m. came from the research budget of the Community and the remainder from a shared cost scheme between participating partners. A total of 1061 proposals were presented by 1986 and 201 got underway in the five technical areas. 142 produced concrete results, 44 are still under development, and 44 were transferred outside the programmes (EEC, 1987). The second phase of ESPRIT has an estimated budget of ECU 3.2 bn.The previous five technical areas have been compacted into three: microelectronics, software and applications (English & Watson Brown, 1985:119).

Companies can participate in the ESPRIT programme in cooperation with universities. In order to participate industrial enterprises must be involved in informatics and carry out their activities within the European community. From 1984 to 1988, 420 different participants from industry, universities and research institutes have participated as partners in projects, of these there were a total of 240 different industrial partners, and 60% of the projects funded included firms with less than 500 employees (SME's) emphasizing the support given to smaller industrial outfits. Project members are organized in 201 consortia with an average size of 5.1 partners per consortium, a figure that included also non-industrial partners who participate in 150 of the 201 projects (EEC, 1987).

ESPRIT's objectives have been to boost cross border cooperation, to develop new technologies, and to create EEC wide standards. Further, ESPRIT aims at concentrating research efforts on the development of powerful processors, on creating comprehensive world standards for software, and designing a set of common European procedures to achieve the necessary flexibility and fluidity in information between different equipments, systems, and activity areas as well as to prepare an European platform for standards negotiations. In Oct 1985 the first review report declared that "ESPRIT had been highly successful in promoting cooperation between large and small organizations and between industry, academia and research institutes" (UK:DTI, 1987).

Bearing in mind the broad programme objectives, the ESPRIT scheme has been able to provide value above and beyond that which can be achieved by national programmes or isolated R&D actions taken by individual firms and individual nation states. The British government has recently extinguished its national informatics collaboration programme -- ALVEY, for its duplication of technical area research

pursued by ESPRIT. Furthermore, the programme draws to itself previously scattered resources both in labour and financial terms; it provides an increased choice of options, it accelerates research and its exploitation, which is of particular relevance in a sector of fast technological development and short product life cycles, and together with EC policies it finds a favourable environment to translate R&D into economic success.

To conclude, the implications of these more recent trends of capital internationalization are very hard to measure. International collaboration and product based industrial consortia is one among many other ways capital has at its disposal to maximize rates of accumulation. Experiences within the AICs suggest that collaboration and cooperation offer new opportunities to countries and regions wishing to enter technologically intensive industries like informatics. These initiatives have not yet taken place in the NICs. Their experience will be discussed in Chapter three.

2.6 Summary and Conclusion

This chapter centered on the global scale of the informatics industry focusing on three main issues: the global economy, economic growth models and the uneven impact of the first two on technology, labour and industrial organization in the AICs.

First, the chapter examined the main features of capitalist crises and booms from 1950s to 1980s during what regulation theorists called a Fordist regime of accumulation, and how Fordism has affected the development of informatics industries in the United States, Japan and Europe.

Second, three growth models were reviewed. The first model, headed by leading American transnational corporations, dominated the world from the 1950s to the late 1970s. American strategies and solid investments in military R&D influenced governments and companies outside the United States to formulate their own national development strategies. Japan emerged as an international competitor to the US in the late 1970s and it has kept a firm control of technologies in many sub-sectors of the electronics complex. In response to American and Japanese strategies a few European countries have developed national informatics policies and industries. However, ridden by economic decline in the late 1970s and 1980s, European companies and governments sought new ways to gain control of their national markets and to support regional developmental efforts through collaboration and cooperation. Lastly, the chapter examined the impact of Fordism (and the crisis of) on technology, labour markets and

industrial organization.

The review of Fordism illustrated the changing character of the global economy. Changes in the global economy have affected the industry's international division of labour over the past 40 years. Behind the global economic scenario lies government's concerns. The state acts by designing policies that respond to a country's needs. It has been shown here that policy options designed in support of informatics industries worldwide range from a liberal 'hands off' approach of the Americans, to a more specific and centralized planning structure of the Japanese model.

This chapter has shown that both the global economy and the state have had an impact on technology development, labour markets and industrial organization (including new spatial arrangements). Of extreme importance is the finding that the informatics industry in the AICs is not homogeneous.

To demonstrate the unevenness of this industry in the AICs this chapter focused on the relationship between industrial development and employment.
In the first instance, during informatics' infant industrial phase, firms were concentrated in the US. American corporations retained the control over technologies and technological trajectories. Their labour demand was for highly skilled and capable R&D personnel.

Secondly, with standardization and product diversification, there was a rising demand for less skilled labour. Rising labour demands conflicted with emerging labour needs. Inside the AICs this demand can be met with the redeployment of personnel from more administrative and less skilled production functions to higher skilled production, R&D, consumer support division, or it can be met with employment of emigrants to work in sweat shops. Companies were also freer to relocate parts of the production activity to other parts of the world. To cope with profit squeezes in the AICs, the relocation alternative was also a way of countering increasing production costs. Concurrent with price cuts relocation brought a split of the production process between production and conceptualization which in fact meant that the crucial social component of technological development remained in the developed nations. This will have a direct impact on the sustainability of informatics industries in the NICs. Parts of an already fragmented production process are transferred to developing countries.

A third possibility has been associated with shifts in employment and a growth in the labour markets in the AICs, represented by a renewed demand for skilled

personnel. As the industry grows mature in the new sites, and provided that states actively participate in the development process, a change in labour demand is expected. These changes in demand may include the introduction of automation both in the AICs and NICs, and a surge of FDI inside the less developed areas of AICs, and isolated, but significant patterns of plant closures in the NICs. The discussion on labour markets and spatial arrangements reiterated the uneven features of this capitalist industry. In the quest for a continued expansion, following what Smith describes as necessity of capital to overcome its own tendency to differentiation through competition, capitalist firms and states seek strategies to mediate these inequalities.

This chapter also discussed new strategies of industrial collaboration focusing on the experience of the EEC and argued that recent trends towards multilateral cooperation is one way capital has at its disposal to get around bottlenecks of accumulation.

The position of the NICs in the global economy, and in the technological and market battle between American, Japanese and European TNCs is not entirely promising. Chapter three below examines the implications of AICs' strategies for the development objectives of the NICs, still within a global framework of analysis.

CHAPTER III

III Articulating with a World Logic: Informatics in the Newly Industrialized Countries

3.1 Introduction

This chapter focuses on the development of informatics industries in selected newly-industrialized countries in South-East Asia and Latin America. The chapter complements Chapter two in providing the international background against which the Brazilian experience is compared in Chapters four to seven below.

Argentina, Brazil and Mexico, in Latin America; Taiwan, South Korea, Hong Kong, Singapore, Malaysia, Thailand, Indonesia, the Philippines, India and China in Asia have all developed national informatics industries. Most of these industries have been studied individually or as a part of comparative industrial studies (Adler, 1987; Breheny & McQuaid, 1987; Correa, 1988; English & Watson Brown, 1985; Grieco, 1984; Humbert, 1986; Okot-Uma, 1990; UNCTAD, 1978; UNIDO, 1985). Other studies focus on the political economy of industrial development in these regions (Cho, 1985; Delapierre & Zimmermann, 1986, 1987; Henderson, 1989, Scott, 1987, Zimmermann, 1986).

The data available about the experiences of developing countries in creating national informatics industries is scattered and not easily comparable. Nevertheless, it is possible to examine existing national policies used to develop local informatics industries in terms of technological development of these industries, changes in the labour markets, and the relationship between industrial and regional development policies that have come in parallel to the development of informatics in these countries.

Summarizing previous discussions, Chapter two illustrated that AICs governments have taken an active role in the development and internationalization of informatics industries. The review of the three regimes focused on important links between political, technological and economic issues permeating the development of informatics industries in those parts of the world. The chapter also focused on the role of TNCs. These TNCs have been given the support and backing of their home states which facilitate the control of technological trajectories and world markets. It was also indicated that the development of informatics industries in the AICs was not a

monolithic or homogeneous process, but an uneven structure of producers and consumers located in developed and underdeveloped regions inside and outside these countries.

In the review of global economic trends and following the proposition of the regulation theory, the main features of Fordism were summarized over the last 30 years and the cycles of booms and crises of capitalist development, explained. The informatics industry emerged first in the United States and has experienced a fast growth rate in the US, Japan and Europe in spite of periods of economic crises in all these three regions. This process of growth has extended beyond the AICs to include many NICs. Industrial expansion into the NICs has been linked to the relocation of TNCs operations beyond national boundaries; to the existence of adequate industrial policies targeted at this sector, and through the emergence of national companies seeking high risk and potentially high rates of return in these new industrial sectors.

Chapter one compared and contrasted different theoretical interpretations of Third World industrialization highlighting the one-dimensional view of some of these theories. In the case of dependency, development takes place in more advanced countries at the expense of the perpetuation of underdevelopment elsewhere. Developments in the NICs and the emerging complex regional divisions of labour inside South-East Asia contradict these interpretations of the dependency school. This theory is, therefore, not appropriate to explain developments in the NICs.

The NIDL thesis focuses on growth and on the relocation of productive capital from the AICs to the NICs. Predominant through the 1960s and 1970s in the textiles and electronics sectors, this process of internationalization was heavily based on cost reduction strategies (e.g., cheap labour markets) (Chapter one, 1.3.2) pursued by TNCs, and not on local initiatives and strategies for sustainable development. In addition, these two theories underestimate the role of the state in shaping the development process, and the role of national capital and its vested interests in the industrialization of their specific countries (Chapter one, 1.4). Regulation theory offers a framework of analysis centred on the role of the state and on a broader set of criteria to explain and measure development. These are helpful in understanding complex developments both in the AICs and NICs.

Chapter one also discussed the uneven nature of development linked to the nature of capitalism and pointed out how it has been overlooked by the literature. Unevenness

is both geographical and social. The concentration of individual and particular capitals in selected economic sectors and parts of the world depicts a cyclical process of capitalist accumulation characterized by crisis and boom. The latter is expressed by different production processes, levels of labour skills, and organization inside factories and offices in and between industries located in the NICs and AICs. The discussion about the experience of the NICs in developing national industries in this chapter will illustrate these points.

3.1.1 Structure of the Chapter

The chapter has seven parts. After this introduction section 3.2 examines the position of the NICs in the global informatics industry. Section 3.3 reviews the role of governments in developing policies to support these industries. Section 3.4 focuses on technology transfer. Section 3.5 examines changes in labour markets and employment in this industry. Section 3.6 reviews regional development policies that have been developed together with or parallel to policies to foster the informatics sector, to maximize industrial development in these countries. These include science parks and special development zones. Section 3.7 summarizes and concludes the chapter.

3.2 The NICs and the International Division of Labour

Different countries have used different development strategies to support industrialization, which as stated in Chapter one, is a precondition for economic development (Chapter one, section 1.2). The uneven pattern of development inside the Third World calls for a more focused classification of countries according to some common denominators.

Ernst & O'Connor have identified the NICs using a broad set of criteria which is appropriate for this study. These criteria include the size and structure of demand for industrial products and related services; the share of industrial manufacturing in gross national product, industrial structure and firm size; backward and forward linkages, the existence of subcontracting networks; the sources of technology; the role of the state and lastly the international competitiveness. Their classification of NICs is fivefold embracing:

i. First-tier Asian NICs: Hong Kong, Singapore, South Korea and Taiwan;

ii. Second-tier Asian NICs: Malaysia, Philippines and Thailand;

iii. Large Latin American Economies: Brazil, Mexico and Argentina;

iv. Next tier Latin America: Chile. Colombia, Uruguay and Venezuela;

v. Quasi continental Economies: China and India (Ernst & O'Connor, 1989:11).

These definitions do not attempt to equate countries to each other specially when the differences between them outweigh their similarities. They do provide, however, a background against which to analyze the performance of countries and regions vis-a-vis each other, and set the context for an analysis of the Brazilian experience.

As mentioned in Chapter two, the 1970s were a period of turmoil and transition for the world economy. Following long, post war expansion, gross domestic product (GDP) growth in industrial countries became more erratic. For the decade as a whole it declined to 3.1% a year compared with 5.0% during the 1960s (World Bank, 1988:13).

In the so called Third World, the situation was more complex and intimately linked to events taking place in the AICs. Between 1964 and 1983, for example, Brazil, Mexico, Hong Kong, Korea, Singapore and Taiwan increased their share of total market economies' GDP from 3.5% to 6.2%, and of manufacturing value-added from 3.1% to 6.6% (OECD, 1988). The economic output of these six NICs together grew at an average annual rate of 8.4% between 1964 and 1973, falling to 5.3% between 1973 and 1983 (Financial Times, 1/08/88). This compares with a 4.1% and 2.1% growth in the OECD countries for the same periods (1964-1973 and 1973-1983). This relatively strong performance was achieved by a "rapid accumulation of external debt and - in many countries - at the expense of growing domestic imbalances" (World Bank, 1988:13)

The patterns of industrial development pursued by the NICs first involved strategies of import substitution and protectionism. These have been followed by more outward-looking, export-oriented strategies.

The transition from protectionism to liberalism has varied from case to case in response to one or more of the following factors: limited domestic markets, under-utilization of installed capacities, or decreasing rates of profits in domestic markets. The increased participation of the NICs in export markets for manufactured goods, in turn, is linked to two factors. On the one hand, export promotion strategies pursued by NICs; on the other, the presence in the NICs of TNCs subsidiaries from the United States and later Europe and Japan, whose business was largely export oriented (Financial Times,

01/08/88). "Thus, to a substantial degree the NICs challenge has been shaped, to the advantage of both parties, by the industrialized countries themselves." (OECD, 1988). Along similar lines, another observer argues:

> "Economic reorganization within Western capitalist societies is in turn inextricably bound up with a major restructuring of the international division of labour associated with the rapid ascendancy of the newly industrialized countries (NICs), particularly in South-East Asia, and with a dramatic intensification of international competition and capital mobility... The cheap labour advantages of the NICs have enabled their industries to capture increasing shares of the domestic and export markets of the advanced nations, while at the same time the low cost and expansionary economic environments in the NICs have proved increasingly attractive to western-based multinationals which have shifted capital, production and hence jobs to these more profitable sites." (Martin, 1988:4)

The growing links between AICs and NICs are more complex than the interpretation put forth by 'development of under-development' theorists, who saw the NICs as satellites for the AICs. Furthermore, developing countries are not an homogeneous bloc of nations. They differentiate in terms of their resources, their development models, and policy choices to manage their development. They also differ in the extent and internal perception of the development of their social, economic and political structures. The following section, looks at the position of the NICs in the global electronic context.

3.2.1 The NICs and Global Electronics

The participation of the NICs in world informatics and electronics industries is on the increase. Yet this is a difficult claim to measure and must be put into perspective. Data covering the most common indicators (e.g., market size, industrial output, employment, trade, installations and presence of foreign companies in the country) are not always available, and when so, are hardly comparable (Correa, 1988).

To situate the NICs in the international division of labour I look at trade flows between regions. Second, the development of Third World markets for informatics goods needs to be examined and the quality and quantity of installations and the types of utilization and application of computers commented on.

a. Trade Flows

Table 3.1, Trade Flows in Informatics, shows that in 1982 countries outside of the United States, Japan, and Europe ('rest of the world') had a trade deficit of US$6,319 million (US$ 14,107m in imports and US$8,284m in exports), compared to

Europe's trade deficit of US$3,764m. Most of the export activities in the NICs are in the hands of subsidiaries of TNCs from the United States, by far the single largest source of foreign direct investment, and the main home country of these companies. Most of these companies are located in South-East Asia (Morgan & Sayer, 1988:107, Scott, 1987:143, UNCTC: 1986, Ernst & O'Connor, 1989:29).

With respect to technology flows, also in the 1970s, American companies headed the list of suppliers followed by Japanese and European based companies whereas the rest of the world played a marginal role. According to Ernst & O'Connor since early 1970s about two thirds of the international supply of disembodied proprietary technology has been of US origin, with the United Kingdom as a distant second.[1] (Ernst & O'Connor, 1989:29).

Table 3.1
Trade Flows in Informatics, 1982 in US$ million

Region	*Total imports from other parts of the world*	*Total exports to other parts of the world*	*Trade Balance*
USA	7,795	13,005	+5,210
Japan	595	5,368	+4,773
Europe	9,036	5,272	-3,764
Rest of the World	14,603	8,284	-6,319

Source: Based on Morgan & Sayer (1988:107)

Figure 3.1 compares the production of electronic data processing equipment in selected developing countries. The data refers to the total industrial production of computers and peripherals, including those for export, of leading NICs based informatics industries. These figures give an aggregate illustration of different regional roles. They do not, however, allow for a more qualitative comparative analysis of informatics industries in the named countries.

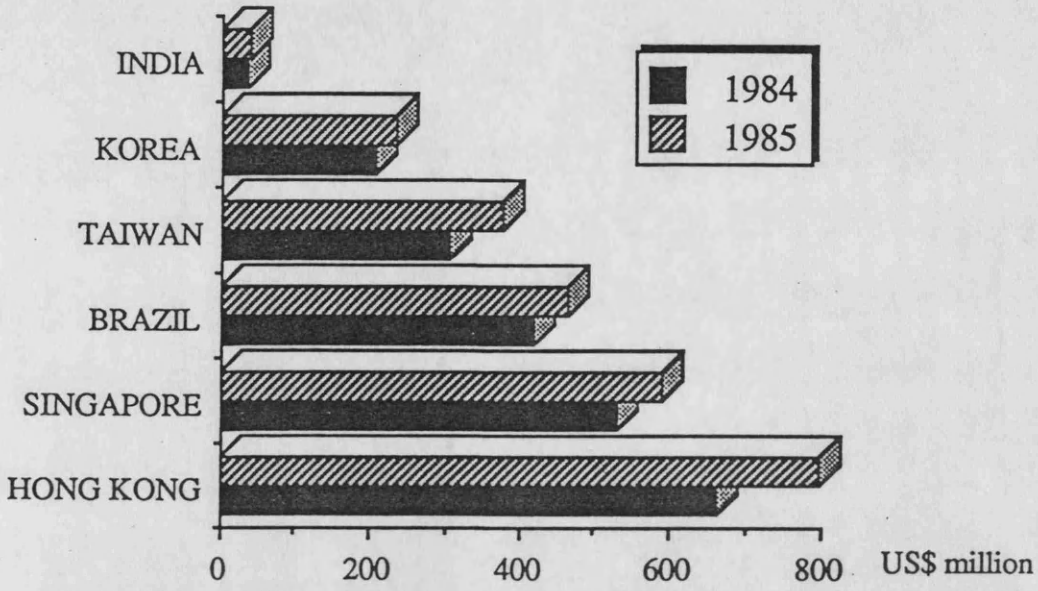
Table 3.2, in turn, compares the participation of developing countries in the global electronics complex to that of Japan and the United States. According to Vasquez & Zimmermann (1988), when compared with AICs producers, the position of the NICs is limited. India's electronic data processing output, for example, comes to no more than 10% of Brazil's electronics production in 1985, which in turn, is slightly less

[1] This information is based on the OECD collected indicator - national technology balance of payments (TPBs) which covers only part of the international technology flows (sale of patents, licensing agreements, provision of know-how, and technical assistance) (Ernst & O'Connor, 1989:30).

than 1 - 2% of American and Japanese figures for the same year. These comparisons, as cautioned by Correa (1988), have to be used sparsely. They serve the sole purpose of providing a macro view of the position of countries vis-a-vis each other.

Figure 3.1

Production of Electronic Data Processing Equipment



Source: Macintosh Yearbook of International Electronics, Data 1985.

Table 3.2
Production of Electronic Data Processing Equipment
(in millions of US$)

Country	*1984*	*1985*
India	36	40
South Korea	208	235
Taiwan	305	377
Brazil	416	463
Singapore	530	588
Hong Kong	664	796
Japan	18365	20909
USA	42409	47069

Source: Vasquez & Zimmermann (1988:45)

b. New Markets for Informatics Goods

The NICs and other Third World countries are a growing market for finished informatics goods coming from developed countries. The demand for computer systems increases year by year, having jumped up sharply since the appearance of the

microcomputers in 1980. Even so, for every 1000 computers installed in the world, only 60 are installed in the developing countries, of which 36 go to Latin America, 18 to East Asia, and the remaining 6 to the rest of the world (Vasquez & Zimmermann, 1988:44). This distribution is very uneven. Latin America ranks first amongst developing countries with computer installations, whereas Africa has very few. Data comparisons are difficult, however. Table 3.3 compares hardware installations throughout the world.

Table 3.3
Hardware Installations in the World

Country or region	*Number of Installed Systems per million inhabitants (Mainframes)*	*Value as % GNP*
USA	248	2.5%
Western Europe	131	1.3%
Japan	208	1.5%
Asia & Australia	1	0.2%
Latin America	15	0.5%
Africa (except South Africa)	2	0.1%
Middle East	4	0.2%

Source: CEREM (1984:29). L'Informatique dans le pays en developpement. Pour une politique de innovation en cooperation. Paris

While computer systems are becoming more common throughout the world, computer usage is still quite restricted. That is, computer applications are developed by sellers of the technology, rather than being primarily developed by NICs themselves to respond to specific needs. As one observer suggests "With rare exceptions, these installations are based on the definition of needs and on software designed and produced by international suppliers." (Correa, 1988:4).

Amongst informatics producing countries, computers are already widely used in both process and product technologies. In South Korea firms use computers to aid assembly and quality control tests of output. In Brazil the industrial sector in 1986 and 1987 was the largest consumer of Brazilian made informatics goods absorbing 31.9% and 33% in each year respectively. Banking and the finance sector came second with 21.1% (in 1986 and 1987), and commerce came third with 21.5% and 19.2% for the same two years (SEI: 1989:23). In Africa, on the other hand, as well as in a number

of countries with very restricted access to informatics, computers continue to be introduced primarily in the public sector to perform larger calculations (Okot-Uma, 1990).

To conclude, developing countries are a market for informatics goods produced domestically or imported from Europe, Japan, and from the US. Section 3.3 below examines the development of informatics industries in East Asia and Latin America.

3.3 The State's Role in the NICs: Regional Divisions of Labour

This section looks at different government policies designed to develop the informatics sector and the results of liberal and/or protectionist policies on industrial development. Differences in industrial performance between and within South-east Asia and Latin America reflect the ways these countries integrate themselves and participate in the global economy and the ability of policy makers to formulate effective polices.

Countries in both Latin America and South-East Asia have managed to enter the international industrial race for computer production. Together they make up the second exporter of informatics goods (after the USA), and the fourth consumer market for informatics products (after Europe, Japan and USA). The number of installations, the quality and quantum of national industrial employment, and the industrial output for their internal and external markets are on the increase. But, as argued in the previous section, there are considerable differences inside this group of producers. These differences are defined in terms of the scope, scale, production process, technology and market of their indigenous industries. The following section illustrates some of these differences.

3.3.1 South-East Asia

Following the classification put forth by Ernst & O'Connor, this region comprises three groups of countries with informatics and electronics industries - the first-tier Asian NICs (Hong Kong, Taiwan, Singapore and South Korea); the second-tier Asian NICs (Malaysia, Thailand and Philippines) and the two quasi-continental economies of China and India (Ernst & O'Connor, 1989). China and India will not be discussed here.

While there are significant differences in the approach taken by each country to

develop indigenous industries it is possible to identify common characteristics within each group. The first four countries forming the first-tier Asian NICs lack natural resources but have an abundance of labour on the basis of which they have built their industrialization strategies. They all have pursued primarily export oriented growth strategies aimed at dynamic market segments, offering low production costs and low cost skilled labour (Santos & Ferreira, 1987).

The structure of production in these countries include very large conglomerates, or the *chaebol,* from South Korea; the traditional TNC subsidiaries (Hong Kong and Singapore) whose locational choice had much to do with an already advanced stage of development and political stability of the two city-states; and lastly, the small to medium scale firms of Taiwan. With respect to the Korean case, the national policy parallels strategies developed in the AICs to strengthen the national conglomerates. There are four large Korean conglomerates Goldstar, Samsung, Hyundai and Daewoo. They play an important role in consolidating the country's position in the international markets (Henderson, 1989:65).

In all but one case (Hong Kong), the governments in these East Asian countries have a key role in designing industrial policy and fomenting local R&D capacity, both necessary pre-conditions to attract new industries. Governments have also supported national capital to take risks and enter these new industrial sectors. South Korea followed the Japanese strategy of the 1960s, implementing a policy of import substitution and supporting its national firms. After years of relative protection (1960s), South Korea adopted a more liberal strategy in the 1970s open to international investments (Santos & Ferreira, 1987).

Foreign technologies continue to play an important role in the developments of national industries in Asia. Countries rely on different sourcing strategies including foreign direct investments (Singapore, Taiwan), original equipment manufacture (OEM) (Singapore, Taiwan) licensing, reverse engineering and disembodied technology (South Korea) (Ernst & O'Connor, 1989:65).

Second-tier Asian NICs on the other hand, are resource-rich and their choice of industrialization has been based on the production of exportable commodities. These are mainly labour-intensive, low-value-added products. National industrialization strategies rely heavily on foreign direct investment, an area that has received attention from the state. On the whole, however, the governments of Malaysia, the Philippines and

Thailand have not taken an active role in supporting the development of local R&D capacities and infrastructure (Ernst & O'Connor, 1989:40).

Asian NICs have chosen different entry markets for their national industries. Particularly amongst the countries of the first-tier Asian NICs, development programmes targeted a comprehensive approach to the development of industrial complexes. Investments were equally made in the semiconductor and consumer electronics in the 1960s, and, in the 1970s, these were extended to include computer production, By 1979, these countries accounted for 71.8% of the world supplies of radios, 52.8% of tape recorders and 45.6% of black and white televisions (Piragibe, 1986:43).

This approach to industrial development, consisting of a build-up of a national capacity in a number of sectors of the electronics complex, helped the position of these four countries vis-a-vis other competitors (Santos & Ferreira, 1987:78). They also follow similar strategies developed by France (the idea of the *filiere*), and by Japan, both cases already discussed in Chapter two above.

South Korea and Taiwan have benefitted from their experience in the production of televisions to become exporters of video monitors. Singapore relies on its experience in precision mechanics to produce competitive magnetic discs. To make these peripherals compatible with the central processing units (CPUs) of leading brands, East Asian producers established technical links with major TNCs producers. Following the Japanese model, they use OEM contracts between local firms and the TNCs as a way to guarantee quality and reliability of products and to promote the development of local products.

South Korea has been very successful in the semiconductors market (computer memory). National conglomerates have increased their share in the world market for 256 D-RAMs (Random Access Memory) to 6% in 1986 and 9% in 1987 (Ernst & O'Connor, 1989:28).

The accomplishments of some of these national industries contrast the proposition of the NIDL thesis that the driving force behind American foreign direct investment in SE Asia on the 1960s and 1970s was essentially low labour costs (Froebel *et al*, 1980). A more recent empirical analysis of hourly wages in the region indicates that these costs have not remained stable with the arrival of branch plants. Scott demonstrates that the cost of manual labour in countries with higher levels of development (again in the first-tier Asian NICs) increased relative to wage values in

other areas of East Asia. From 1969 to 1983, South Korea, Hong Kong, Singapore and Taiwan had average hourly wages above the US$ 1 mark. Table 3.4 illustrates these differences.

Table 3.4
Hourly Wage of Production Workers in South-East Asia

Country	*1969*	*1975 (US$100)*	*1985*	*Average Wage (US$)*
Hong Kong	10	12	16	1,33
Indonesia	n.a.	05	04	0,35
Korea	10	7	14	1,19
Malaysia	n.a.	9-10	10	0,84
Philippines	n.a	06	08	0,63
Singapore	09	12	19	1,58
Taiwan	08	07	16	1,36
Thailand	n.a.	05	05	0,43

Source: Scott (1987:145)

In addition, this wage increase is relative to an overall increase in skill levels in some of these countries. Singapore, for example, has developed a two-step strategy to attract foreign direct investment. During the first phase of capital internationalization, in the 1960s, the country offered a large pool of unskilled and cheap labour. At the second stage, starting in the late 1970s, Singaporean labour was better trained as a way to attract less labour-intensive assembly activities and more technologically intensive operations (Henderson 1989:68).

South Korea, like Singapore, has a long standing tradition to train national labour and offer competent engineers and technicians to be employed in the national industry. These labour training strategies include support to develop national skills. Policies to raise the skill levels of national labour have given both these countries the opportunity to move their industries from a position of mere assemblers of electronics equipment to more technologically intensive production operations. (Ernst & O'Connor, 1989)

The Taiwanese industry moved from being a desirable location for branch plants to one of the world's largest producers of compatibles (e.g., Tandon Computers). The arrival of assembly plants in the country incited inter-firm competition. These firms were exposed to international competition inside their national territory from the very

beginning of their operations. To remain operational and to succeed, they made themselves competitive producers of clones and invested in R&D. Once in control of basic computer technology they moved into large scale production of computers and used aggressive marketing strategy to reach international markets (Henderson, 1989).

Relying on comparative advantages of a trained labour force, companies located in Taiwan and Singapore have moved into the development of software in oriental languages as well. These companies also supply low technology components to the Japanese market, taking advantage of geographical proximity and interest from the part of Japan to invest in the region (San, 1990:26) This close relationship between companies located in the first-tier Asian NICs, and those in Japan, has positioned the former in a superior position vis-a-vis European, American and Latin American producers to operate in the region and to penetrate the tight Japanese business environment.

To summarize, different approaches to developing electronics industries in East Asia have resulted in unique divisions of labour in the region. The first-tier countries, today, have managed to widen the gap with other Third World producers in the technological race (South Korea and the production of RAMs mentioned above). The use of OEM contracts with Japanese and American manufacturers has contributed to this success.

Relying on a population with a good educational level and a high number of engineers and scientists [1], the emphasis on the development of a trained labour force in the production of hardware and software has given some of these countries a comparative advantage in the production of software. In the span of 40 years companies located in the first-tier countries have moved from industrial activity initially characterized by assembly-type, labour-intensive and low-skilled production to more technologically sophisticated operations involving the production of entire computer systems, and their marketing in western and eastern markets (Henderson, 1989).

The export-oriented option adopted by most governments in East Asia, bear positive and negative implications for the economic longevity of these industries. One of the problems of export orientation is a dependency on a structure for which decision

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[1] Ernst & O'Connor compare the level of education between South Korea and other NICs and AICs. They pointed out that in 1983 the first had 800 R&D scientists and engineers per million population against 375 in Argentina, 4,000 in Japan and 3,000 in the USA. In the same year, Korea had 277 000 tertiary engineering students, Mexico had 257 000 and Brazil, 165 000 (Ernst & O'Connor, 1989:56).

centres are not located in the developing countries but outside, where the investors (TNCs) are. Thus, changes in the international strategies of these firms can have a direct impact on the economic, social and political spheres of host countries. This is particularly important for countries like Hong Kong, Singapore, Malaysia and Thailand whose production structures are heavily based on TNCs branch plans. On the positive side, international exposure of national productive capacities and national products can bring to industries, provided that they are adequately backed by their governments, the same medium and long range benefits regarding their ability to absorb new technologies and to increase their bargaining power with TNCs operating in the country.

The early exposure to international markets has given local companies a needed opportunity to enlarge their industrial outfits, to achieve optimum economies of scale and increase their commitment and investment in R&D. To a large extent, these countries have managed to maintain a coherence between national policies and international industrial trends in informatics and to secure the necessary ingredients for the development of their national industries.

3.3.2 Latin America

Delapierre and Zimmermann define the development of informatics industries in Latin America in three groups of countries. The first group includes countries engaged in the production of computers such as Brazil, Mexico and Argentina. The second group consists of countries which are heavy users of informatics products and services and which, in order to maximize their bargaining power, have developed use and procurement policies for both private and public sectors. These countries also have a commitment to developing indigenous application software. Venezuela, Colombia, Peru and Chile fall into this category. The third group includes countries which do not have a specific strategy for the production, use or procurement of equipment. They also have no objective provisions to deal with the introduction of computers in their countries. This group includes Bolivia, Paraguay, Uruguay, and other Central American countries.

Ernst & O'Connor have a dual classification of countries in the region including a first-tier (Brazil, Argentina and Mexico) and a second-tier (Chile, Colombia, Uruguay and Venezuela). Both classifications provide an adequate description of production and market conditions in the region.

Countries under the first group (those engaged in the production of computers),

have relied heavily on import-substitution growth strategies focused predominantly on the development of domestic markets. The production structures in these countries include the presence of foreign firms, small- and medium-scale enterprises and larger state enterprises (Brazil). Their combined GDP is three times larger than the combined GDP of the first-tier Asian NICs. Average per capita income is comparable (World Bank, 1987), and income is unevenly distributed (Ernst & O'Connor, 1989:50).

The role of the state is quite explicit in the three countries. Brazil stands at one end with a high interventionist and protectionist approach to industrial policy covering a wide range of areas (different industrial sectors, technologies, production structures). Argentina stands at the other end with a lighter version of state intervention which has been reduced in recent years. However, more important than the degree of intervention, as pointed out by two observers, "state regulation of trade and investment in new technologies has been less focused than in the Asian NICs" (Ernst & O'Connor, 1989:50), which in, turn, has amounted to a dispersal of resources (financial and technological) and the weakening of state initiatives.

Foreign direct investment has been the main source of technology acquisition in Latin America. [1] However, the institutional set up to deal with and regulate FDI in Latin America has in some cases worked against the countries themselves. As two observers remark

> "given a high degree of protection joint ventures with foreign capital have been relatively insulated from import competition and have had little incentive to introduce new technologies to upgrade their operations. Licensing and technical consultancy arrangements have been limited as compared with countries like South Korea. The severe foreign exchange shortages of recent years have reduced technology imports, and even FDI has virtually stagnated as a result of the crisis." [2] (Ernst & O'Connor, 1989:51)

Lastly, education levels in Latin America are lower than in the more advanced Asian economies (Unesco, 1986). Brazil has a large number of technicians, engineers, and master and doctoral students in science-related areas, the highest in Latin America (see section 4.4 below). These figures, however are below those of South Korea, the

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[1] See *Conjuntura Economica*, Jan 1988:7-8 and Jul 1989:119-23.

[2] UNCTAD, Trade & Development Report, 1987:86-91.

Asia country with the highest education level. [1]

The following section focuses on Brazil, Mexico and Argentina.

a. Mexico

Mexico decided to develop a national informatics policy in response to a internal economic crisis that started in the late 1970s when, after 30 to 40 years of implementation of import substitutions strategies, Mexico realized that national development and achievements were far from enough to place the country amongst the group of industrialized economies (Humbert, 1986:67). The Mexican policy for informatics initially had very ambitious targets. The policy was based on the granting of incentives, import restrictions and the acceptance of foreign participation only in joint ventures (Correa, 1988:16). The policy stated among other things that within the first five years of its operation, the national industry should supply 70% of the internal demands for informatics (Cline, 1987:110).

Influenced by the geographical proximity to the United States, Mexican policy makers opted for not having an explicit form of protection over production, fearing that such a protection could stimulate contraband along the borders. As a result, each market sector is treated differently. Mainframes can be freely imported. They are not produced inside Mexico. Minicomputer manufacturing is in the hands of wholly-owned foreign corporations to restrictive measures and having to export part of their output. Microcomputers are manufactured and sold competitively both by Mexican and international producers located in the country.

Foreign presence in other sectors of the electronics complex is common in the country. In telecommunications ITT, Ericsson and Standard Electric control the country's telecommunication activities. In consumer electronics RCA, General Electric, Phillips, Sony and Zenith set up assembly plants in the country in the 1960s to produce circuit boards, cases and other sub components for television production (Humbert, 1986:84). By 1986, Mexico produced one third of the television parts and components consumed by North American markets (Piragibe, 1986:91). Mexico is also one of the largest semiconductor assembly platforms amongst the NICs Toshiba, Phillips, Motorolla and Mitel have branch plants assembling integrated circuits (Humbert,

[1] The density of scientists, engineers and technicians in Brazil is 25% less than that of South Korea. The proportion of tertiary students in engineering in Latin America is half that of South Korea (Amsden & Kim, 1986:110).

1986:84). With such a significant presence of foreign capital in the country, it has been very difficult for Mexico to keep foreign interests away from its informatics sector.

R&D facilities and other support to S&T is limited. According to Humbert it is difficult to consider that Mexico has a solid S&T base to support its electronics industry. There are 10,000 researchers working in the public sector and 1,200 in industry. Investment in R&D reached US$ 400 million in 1984 (50% less than in Argentina and one third of R&D investments in Brazil) (Humbert, 1986:86).

Up to 1981, informatics goods could be easily brought into the country. Excessive imports did not help the country's balance of payments and increasing foreign debt. To resolve this, import restrictions on informatics goods were imposed in 1981 followed by the approval of nearly 50 indigenous development projects that were to substitute foreign presence on the national market.

Market structures were differentiated by product in Mexico. The mini market was controlled by IBM, HP, Burroughs and Sperry. Apple and IBM were also interested in entering the micro sector. Under the new restrictions, they would have to set up joint venture arrangements with Mexican firms. With few exceptions, TNCs were reluctant to invest in joint ventures. IBM, for example, remained loyal to its corporate tradition and kept putting pressure on the Mexican government to obtain the permission to set up a wholly-owned company in the country. After a few attempts, in 1984, the government accepted IBM's demands, IBM set up a factory in Mexico to produce micro computers. The investment totalled US$100 million, the plan has a capacity to produce 200,000/computer year, and the company agreed to export 92% of its output (Cline, 1987:115).

The approval of IBM's proposal affected the country's policy. For one, Mexico's original policy of 1981 was never formally approved. The lack of an institutionalized policy base contributed to the approval of IBM's proposal. The arrival of this TNC also brought change to the local industry. IBM's production for export helped to alleviate a negative trade balance in the sector and to bring much needed foreign currency to a country sinking under foreign debt. The local industry also benefitted from IBM's agreement with Mexico to set up a R&D centre for the development of semi-conductors and to source its demands for electronic components from Mexican companies. This arrangement was part of the deal to set up a 100% owned company (Humbert, 1986:90). After IBM, Apple and HP have followed suit to obtain similar treatment from

the government.

Mexican export activity in informatics has increased. However, the types of export coming out of Mexico are not associated with a parallel control over the technologies imbedded in these products as most export activity is generated inside TNCs.

Mexico is in a similar position of East Asian competitors when it comes to its relationship with American capital. Mexico has been a site for US investments from the 1960s onward. Because of this relationship, expanded to other sectors of the electronics complex, the government has always been restricted in playing a more important role to defend national objectives. By and large, Mexican based TNCs make it very difficult for Mexican corporations to expand their market share and to create brand names of their own. As Humbert points out "the crucial question remains if Mexico can develop a truly national industry based solely on the activities of TNC's and joint ventures operating in the country" (Humbert, 1986:91). The possibility that a national company or champion could be created, according to Humbert, is impossible. The future for sustainable national development in this sector is, as a result, unknown. Also, given present economic bottlenecks, it is unlikely that the government could impose restrictions on the existing industrial activities of leading TNCs, (as India managed to with IBM in the mid 1970s) (Grieco, 1984).

b. Argentina

Argentina's approach to developing a national informatics industry sits at the opposite end with direct industrial market protectionism and state regulation. As with the other two, Argentina practiced a policy of industrialization through import substitution up to 1976. Import substitution facilitated the development of some industrial sectors in the country. In terms of electronics industries, the consumer electronics sector was developed and supplied most of the country's internal demand for these goods. 80% of the goods consumed were locally produced (Piragibe, 1986:80). The absence of any protection for the semiconductor sector allowed Argentine consumer electronics producers to acquire technology and product diversification. At the same time, the country's internal market provided the optimum scale for the national producers, and local production kept pace with the international markets.

After 1976, liberal polices favoured the exposure of Argentinean markets to foreign competitors. This resulted is a slow but fatal destruction of national capacity and

competitiveness in the sector, exposed to a newly-arrived wave of Japanese producers setting up their assembly plants in the country.

In the realm of informatics IBM, Olivetti and Fate (Argentina) controlled, up to 1974, the domestic informatics market. However, technological changes in product design affected the trajectories of these companies. Olivetti, with the advance of electronics technology, shut down its plant in Argentina. IBM maintained its activities producing primarily electro-electronic products (e.g. printers and magnetic drives) as part of the company's international division of labour. Fate, producer of electronic calculators, could not cope with foreign competition and went out of business by 1980 (Zimmermann, 1986).

By 1984, the market for computers and peripherals remained largely controlled by imports from the US. IBM concentrated over 70% of the total national computer market (Correa, 1988:21).

Inspired by Mexico and Brazil, and by the shortcomings of liberalization policies post-1976, Argentina decided to set up a formal industrial policy for the sector. This policy, together with other strategies, characterizes the country's third and most recent strategy towards the sector.

The new policy's main objective was to give Argentina the capital, labour and environment conducive to learning and developing indigenous technologies, R&D capacity, production and human resources. To create such an environment, policy instruments included tariff protection for certain products, fiscal incentives and the regulation of foreign investments. With regard to the last, Argentina opted out of the promotion of joint ventures between national and international capitals. Bull and Burroughs have accepted the country's terms to operate through local firms (Financial Times, 12/03/85). IBM, keeping up with its tradition has a wholly owned operation in Argentina which was established prior to the new policy. The company produces printers and other peripherals for world markets. The microcomputer sector is in the hands of domestic manufacturers, who also produce peripherals and software (Zimmermann, 1986)

c. Brazil

The Brazilian experience will be examined in greater detail in the next four chapters. Compared to other developing countries, the Brazilian strategy stands out for its level of institutionalization, length and extent of policy, and its explicit military

concerns, as well as for the level of industrialization. The Brazilian navy has been most influential in putting forward a policy to make Brazil technologically competent to manipulate, repair and eventually produce computers and other devices for military purposes. Curiously, the Brazilian case, contrary to France, the UK and the USA (which have the largest portions of their R&D funds devoted to military related research), has not managed to benefit from this relationship as successfully as it did with aircraft and other conventional weapons. These ideas will be dealt with in Chapter Four below.

The experiences of NICs with industrial policy and other forms of state regulation will be explored at the end of the chapter.

The next three sections compare the experiences of the NICs looking closely at three aspects of the development of informatics: technological transfers, changing labour markets and regional development policies. In the first case, the problems NICs face to appropriate, adapt and develop informatics technologies are discussed. The second case, looks at how changing social divisions of labour in the industry have benefitted some industries, allowing them to move ahead in their quest to participate in world markets. The last section examines regional policies that have been put together to attract investors and capitals to particular localities in the world.

3.4 Technological Transfers between AICs and NICs

Common to all policies discussed in Chapters Two and Three is the notion that industrial development policies have to empower national industries to gain greater knowledge, understanding, development capacity and control over key informatics technologies. This view is undisputed amongst development theorists and critics of the development process of informatics industries (Forbes, 1984; Henderson, 1989).

Despite this widely accepted opinion, NICs are faced with concrete barriers to achieve their goals of technological autonomy and industrial competence in many sectors of the electronic complex, including informatics. These barriers touch on but are not reducible to a) technology development, ownership and transfer; b) the development of national S&T and R&D structures, and c) skill level of the national labour force. The definition used in this thesis for technology

> "has to do with certain kinds of knowledge which allow the adaptation of means to ends. Part of this knowledge is embodied in machines, but most of it is not. It is embodied elsewhere -in the brains of people, in organizational structures and in behavioural patterns, which in turn, are conditioned by the strategies of different social factors and their patterns of conflict and cooperation." (Ernst & O'Connor, 1989:20)

The NICs discussed in this chapter are heavily dependent on technologies developed by AICs and controlled to a large extent by TNCs. TNCs are the most important actors in the process of technology transfer. These TNCs together with their home countries are at the forefront of the development process having financial, technical and human resources to carry out the basic and applied research and development which keep the industry going. Furthermore, there is a clear dispute between leading producers and consumers of technology and how each group plans to use technology.

NICs have been able to appropriate foreign technologies using different channels. These include: FDI, licensing, reverse engineering, OEM contracts, disembodied technology and of, course, indigenous developments resulting from the transfer. These channels have been used differently by different countries and have changed through time. While the channels have facilitated many successful technology transfers, appropriation has been limited amongst the NICs. South Korea (digital switches and RAMs) and Brazil (digital switches) have managed to develop appropriate indigenous systems suitable to satisfy internal demands. Equally, countries which have been able to develop internationally competitive industries (first-tier Asian NICs) have adapted and developed production and organization processes to achieve these high output levels. International competitiveness, on the other hand, has been possible for these countries through effective control of production costs and pricing policies (Henderson, 1989).

Technology as a part of a country's social relations of production demands the existence of a social structure that is capable of perceiving its own needs, and securing the means of its own reproduction. As a technical activity it demands the availability of research and development facilities and the resources (human and financial) to undertake and pay for experimental and innovative work, and to transform ideas into products. As Cho demonstrated in his comparative study of labour markets in the USA and Korea, these conditions cannot be easily reproduced in a Third World country including most developing countries like Korea (Cho, 1985). The reasons for this are manifold.

The patterns of capital internationalization analyzed in the previous chapter indicated that TNC's internationalization strategies from the 1960s onward did not include the internationalization of the social aspects of technology in the countries where TNCs chose to invest. TNCs activities included the relocation of parts of the productive activity (e.g., assembly), or the setting-up of factories to produce for export, or the setting up of joint venture agreements with local producers. R&D activities and investment have been kept well inside the AICs, as illustrated in table 2.1 above. It was therefore up to the host country to seek the resources to invest in the development of national science and technology programmes, in the training of national scientists, the fitting of research laboratories and so on.

To complement production activities set up by TNCs, nationally based companies, in turn, enjoyed a better chance of developing in-house technologies and adapting foreign made systems to local conditions. These companies and the policies developed by governments to promote national industries tend to choose a more independent path of technological development with a view to achieving a degree of technological competence. The results of these strategies have been mixed. India, for example, in 1978 launched a programme to build semiconductors. Problems in the completion of the project caused a delay of several years in the commercialization of the Indian chip rendering them obsolete even before they came out (Vasquez & Zimmermann, 1988:48). Brazil's first choice of technology to build a mini computer was sold by the British manufacturer, Ferranti. Already obsolete in Europe, the first nationally made computer, the Argus, was an industrial and commercial fiasco. Other attempts, like the development of electronic banking in Brazil, have been extremely successful in the country, and others are extremely controversial, like the case of the 'SOX operating system' developed by Cobra (Marques, 1988).

An alternative to the arduous and expensive road towards indigenous development is to become industrially and commercially competent in production of nationally made computers with technology developed elsewhere. South-East Asian countries have opted for this strategy relying on licencing, reverse engineering, OEM contracts and basic assembly of products for TNCs in order to obtain the necessary technical, production and process skills to make their companies commercially feasible in national and international markets.

NICs face other problems regarding the development of indigenous technologies

in addition to being able to develop and master technology in its three facets. As discussed in the introduction, technology development is an expensive business open to very few players. The interdependency between different sectors of the electronic complex almost demands the presence of different industrial sectors so that one can benefit from the other's technical and commercial developments.

Bilateral and multilateral cooperation in technology and industrial development programmes is practically absent from the experiences of NICs in developing their national industries. As historically established connections link developing countries to AICs, NICs have found it very difficult to break this North-South flow of knowledge and technological transfer and to initiate NIC-NIC technical cooperation programmes.

To summarize, developing countries who have made a decision to enter the informatics sector face barriers in the quest to achieve high levels of mastering, development and control of key technologies, in addition to bottlenecks particular to the electronics complex (already discussed in the Introduction). NICs depend on TNCs to sell them basic production and process technologies that will allow them to enter the informatics sector. As discussed in Chapter two, TNCs' profit oriented objectives, associated with relocation of part of their activities to locations outside the AICs, do not include the relocation of R&D facilities. NICs must seek the means and resources to fully develop the three dimensions of technology, that is: social, creative and technical, in addition to seeking technology transfer agreements with leading TNCs.

Intrinsic to successful and effective technology transfer is the development of a class of national high skilled labourers and of an adequate S&T and R&D programmes to complement the transfer process. In the next section I examine changes in the labour markets of industries located in the NICs.

3.5 Capital Internationalization and Employment: a NICs view

So far it has been shown that, in order to enter a turbulent, global, and highly competitive informatics industry, countries must establish development policies, support from national capitalist groups, S&T funds, R&D facilities and a labour force with the necessary level of skills. This section focuses on the experience of certain NICs to develop a national labour force technically competent in research, development, production and marketing of informatics products domestically and overseas.

Employment in the informatics industry both in the AICs and NICs has

undergone quantitative and qualitative changes since the advent of digital technology in the 1950s.

In a study of employment trends in informatics industries located in the OECD economies, one observer identified three distinct trends:

1) a phase of job creation during informatics infant stage;

2) a period of job stagnation or decline following a period of industrial maturity and geographical expansion of leading world companies; and

3) a phase of shifts in employment from less skilled, assembly type workers to more skilled R&D, marketing, etc. employees (Hewitt, 1988).

In the NICs patterns of employment change parallel employment changes in AICs based industries.

With respect to the first trend - job creation, the experience of NICs based informatics industry can be divided in two periods, one starting in the early 1960s and one starting in the 1980s.

Job decline in AICs countries during the 1960s (described in section 2.4 above), were compensated by job growth in the NICs when branch plants of TNCs arrived in many countries. The types of labour demanded were docile, politically inarticulate, low skilled and low-wage workers, mainly women, to work on large scale, labour-intensive, assembly type jobs.

Comprehensive data on current levels of employment in the subsidiaries of semiconductor, computers and peripherals TNCs located in the NICs are not easily available, and if so, are difficult to compare. Still, it is possible to observe this trend of job creation in the NICs. Taking Singapore as an example, in 1971 there were 28 firms employing 11,847 workers, ten years later, in 1981 there were 182 firms and 67,858 workers (UNCTC, 1986:403). In the Philippines employment grew 20 fold between 1974 and 1981 (40,000 employees). South Korea experienced an increase of 120,000 jobs between 1973 and 1984 (UNCTC, 1986:364). Patterns of job growth and the NICs were soon to change.

After 1980, employment in the United States semiconductor corporations in East Asia declined by several thousands due in part to the global recession, in part to rising labour costs and to political uncertainties. However, it seems that job losses in AICs and NICs occur for entirely different reasons. Job loss in the NICs were linked to changes in business strategies of TNCs and rising tensions inside NICs. The ghost of

world recession called for a massive restructuring of North American and European industries to recover the path of capital accumulation. Restructuring relied heavily on the introduction of new technologies to raise the levels of productivity both inside offices and factories via automation. Thus, by the late 1980s employment levels in the NICs were first affected as a result of introduction of modern techniques inside plants.

The introduction of automation made redundant hundreds of manual workers involved in assembly work replaced by error-free machines. In 1982, Control Data closed its South Korea subsidiary after serious labour resistance to the introduction of automated lines. The corporation justified its action because of technological advancements in the production process [1]. Along with these changes in the process of production and others problems related to unionization, labour unrest and wage demands, as well as concern over workers' housing and basic reproduction of community and family life. According to an international manager of Motorolla Semiconductor group, "the trend for the future is for more and more assembly to take place in the United Sates or Europe" (Business Week 15/03/82).

The impact of these shifts in production trends varies across sectors and countries. Countries occupying what Henderson identifies as the periphery of the NICs, inside East Asian regional divisions of labour, have been more vulnerable to changes in TNCs investment in these countries. These lay-offs are more likely to occur when the control of capital is outside the country, that is in the hands of TNCs. In South Korea, employment by foreign-owned electronics firms decreased from 47,300 in 1976 to 27,200 in 1982 (UNCTC, 1983a) whereas that of its national electronics manufacturers remained the same, and even increased after 1981, after their investments in the USA (Cho, 1985:193).

In Latin America, Mexico was more directly affected by changes in TNCs strategies than Brazil or Argentina given the significant presence of American TNCs. (Fadul, 1987). In Brazil, the restructuring imposed on TNCs activities as a result of the introduction of the national informatics policy in the early 1980s led to a decline in TNC jobs. Employment by foreign-based corporations located in Brazil dropped from 11,797 in 1982 to 7,383 in 1988. In the domestic companies, employment rose from 12,598 to 26,344 for the same period (SEI, 1989:24).

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[1] *Asia Monitor*, 1982, 1st. quarter, in Cho, 1985:193.

The third employment trend identified by Hewitt referred to shifts in employment. In the AICs this shift is associated with a rise in the number of white collar workers involved in R&D, management, marketing, human resource development, customer support systems, software development and so on. Hewitt and Henderson have identified a parallel process in the first-tier Asian and Latin American NICs (notably in Brazil and in the Gang of Four nations), associated with the development of national industries (Hewitt, 1988, Henderson, 1989), and with support to developing national skills and labour training.

To conclude, the impact of technological changes on employment in the NICs can have negative effects on labour supplies if labour protection and support mechanisms are not in place to cope with these changes. The literature discussing the impact of capital internationalization and employment in the NICs is limited (Cho, 1985, Hewitt, 1988; Henderson, 1989). Very little is known on how existing social relations and social innovations introduced by informatics firms affect labour and employment. Judging from the literature, some countries have managed to provide protection and support to their national labour forces and to upgrade their skill levels to attract technologically-intensive industries (Henderson, 1989). Along similar lines, Hewitt identifies a transition from a model of employment based on the intensive use of semi-skilled assembly labour to one that emphasizes the employment of skilled engineering and technical labour in certain sub-sectors of Brazil's electronics industry. This transition is, among other things, a result of favourable political, economic and technological conditions surrounding the national computer industry (Hewitt, 1988). Lastly, Cho, advancing the debate to focus on the impact on labour of more recent capitalist strategies in South Korea, illustrates a case of difficult articulation of interests between AICs and NICs. There, changes in the international movement of capital in the electronics industry parallel a change in the nature of the labour process in the AICs and NICs. This has eroded the latter's comparative advantage in labour costs and cannot be reproduced in the NICs.

3.6 Competing Regional Policies and the Development of Informatics Industries in the NICs

Capital internationalization from the AICs to the NICs during the 1960s and 1970s was not only associated with a particular set of production activities, and labour

profiles, but with particular localities within the host countries. The spatial preferences of both foreign capital (1960s onward) and at a later date, national capital (mid 1970s onward) include locational patterns which can be roughly grouped under three social-spatial arrangements: export processing zones (hereafter EPZs), in and around traditional industrial centres, and science parks. These have occurred between the 1960s to mid 1970s (EPZs), 1970s to mid 1980s (traditional industrial areas) and mid 1980s to the present (science parks).

These social spatial arrangements can also be associated with different types of policies used to fulfil a country's target to upgrade labour, technological know-how, skills and industrial capacity. The lack of substantial data on industrial location in most of the Third World make construction of informatics industrial geographies a difficult task. Taking that into account, this section examines the characteristics of these three periods including the nature of socio-spatial arrangements, and matching policies that have been developed in the NICs. This section will provide a framework of analysis of the Brazilian experience in Chapter Seven.

a. Export Processing Zones

The export processing zones (hereafter EPZs), characterized much of the electronics development from the mid 1960s to the mid 1970s. This periodization, used simply as a model of understanding the industrial geography of informatics in developing countries, does not exclude the development and creation of EPZs in many developing and Third World countries to date.

In 1975 there were a total of 79 EPZs in 25 countries. In 1980, there were 116 EPZs in operation, in 55 Third World countries (UNIDO, 1985). They employed approximately 840,000 people whereas the EPZs of seven countries (South Korea, Singapore, Malaysia, Philippines, Mexico and Brazil) accounted for 62% of this employment.

The principle of the EPZs was to offer foreign investors the infrastructure, labour and import/export tariffs and benefits (e.g., fiscal and tax exemptions, subsidized infrastructure., favourable terms of profit repatriation, etc.) to carry out their operations. Most of these zones were set up to host the activities of multinationals first in electronics (semiconductors and consumer electronics) along with textiles, and clothing. However, electronics remained the largest employer in the EPZs (UNCTAD, 1978:34; Hewitt, 1988:6). EPZs also functioned indirectly as an instrument of

development that operated at a macro (national), meso (regional) and micro (local) levels.

EPZs had a different appeal for governments, TNCs and the labour force. From the perspective of government, the EPZs were a functional institutional and geographical feature attracting trans-national corporations in the host country. These firms had the potential to develop new electronic industrial activities, to create employment, to bring in dollars through exports, and even to have some positive impact on skills and the reduction of the technological gap.

For the second group - TNCs, EPZs brought together the necessary requirements for investment. They provided the infrastructure, support and know-how of a free zone, to make the life of TNCs easier. As labour costs had to be kept low at all times, the EPZs made sure that the companies would have the necessary labour supply at the desired price. EPZs also help TNCs to pre-empt or circumvent protective barriers to uncertain key markets (e.g., Mexico and Brazil in particular), This is part of the Japanese experience in consumer electronics and most recently in computers to overcome barriers inside the USA and European Community (Morgan & Sayer, 1988:116).

For the last group - labour, EPZs provided labour intensive jobs to a large number of workers. These jobs were predominantly performed by semi-skilled women. Young women in 1980 accounted for 88% of employment in EPZs in Sri Lanka, 85% in Malaysia, 75% in South Korea, 74% in the Philippines, 80% in Taiwan and 77% in Mexico (EIU, 1985:3; Hewitt, 1988:8).

The perceived spatial development advantages of the EPZs worked out differently in practice. First, the EPZs provided an institutional background to enhance the inequalities between the foreign investor and host countries. They concentrated their activities around a highly fragmented labour process in a limited range of final assembly activities which limited the possibility of technological spin offs (discussed above in section 3.4). Second, "the absence of strong linkages has not only reduced the possibility of indirect employment generation (e.g., from input supplier), but it has also inhibited the learning process which local firms might undergo through interaction with electronics multinational corporations" (Hewitt, 1988:7). Third, the relationship of dependency described in the concept of the EPZs made them very vulnerable to changes in the international market. During periods of recession, the zones suffered severe

labour retrenchment confirmed in the figures given in section 3.5 above.

By the 1970s the idea of EPZs began to be questioned together with the assumptions associated with the NIDL and their relevance to Third World development.

> "There are grave misgivings as to whether EPZs can any longer be regarded as assembly structures which can make lasting contributions to the net export earnings of developing countries, or serve as vehicles for the transfer of technology by TNCs to developing countries even in industries like electronics, to which zones seemed particularly well suited at the start of the decade (of the 1970s)" (UNCTAD, 1978:33, quoted in Hewitt, 1988:7).

b. Traditional Industrial Areas

The second social spatial arrangements characteristic of the newly emerging national industries in Latin America and East Asia moved away from the institutional (i.e., fiscal incentives and labour dormitories) and spatial (i.e., proximity to ports and airports) rigidities of EPZs to locate themselves in and around more traditional industrial centres. In Latin America, these localities attracted new informatics and electronics firms primarily for their historical agglomeration of electronics and mechanical industries whose diversifications may have led them to enter the electronics sectors. These firms were also better served by larger and higher skilled workers and labour force whose employment choices were enhanced near these industrial clusters. Other locational advantages tended to include better transport networks and communication systems, proximity to centres of decision making (e.g., governments associations, lobby groups) and of course the tight linkages with other economic sectors, the proximity of suppliers and consumers - i.e. the market. The EPZs instead maintained a relationship with the export market expressed by its location near costal zones or airports.

In terms of the types of policy applicable to domestic companies, these tended to be characterized by a greater level of protection, including import restrictions, market protection, more generous subsidies for activities such as R&D and labour training and education, which were not possible, or desirable, in the EPZ model.

The last and most recent social spatial arrangements characteristic of electronics complex and informatics is the science park.

c. Science Parks

Science parks are not necessarily a new phenomenon. The first university related research park of note was at Stanford University in California, in 1952 (Money, 1987:29). According to the International Association of Science Parks, the terms used to describe a property based initiative which:

> "-has formal and operational links with one or more universities, research centres, or other institutions of higher education;
> -is designed to encourage the formation and growth of knowledge based industries and other organizations normally resident on site;
> -has a management function which is actively engaged in the transfer of technology and business skills to tenant organizations." (Dalton, 1987:13).

In addition to these features, science parks are perceived by both developed and developing countries as a catalyst in regional development. The meaning, implications and feasibility of the catalyst to contribute to a country's development process vary enormously from developed and developing contexts.

The experience of science parks in Europe show that there have been three phases of development. The reason for using the European example is because the US and Europe have gone further in the development of these regional industrial development schemes. Most attempts in the developing world are at a too infant a stage to allow any concrete evaluation of results (Anais, 1987).

The first phase of science park development started in 1972 with the opening of the Harriot-Watt Research Park in Edinburgh and the Cambridge Science Park of Trinity College. Both parks were set up by universities in very prestigious and affluent areas.

A second period began 10 years later from 1982/83 when a new wave of parks' initiatives were set up as a part of a broader solution to problems of de-industrialization and economic decline (Dalton, 1987:17). These were to appear in backward areas of Wales, Scotland, Ireland, France and Spain. These partnerships involving typically a higher education institution, a local authority and a financial institution. They were located in areas of traditional industrialization which were, in varying degrees, suffering from recession and overall economic decline (e.g., Provence in France, Bilbao, Madrid, Barcelona, Malaga and Sevilla in Spain).

A third wave of parks began in 1985, when over 20 new parks were created in Great Britain alone and another 25 in continental Europe. These new investments were based on a mix of incentives, policies and organizational structures to valorize new enterprises through the transfer of technology and research experience, innovative ideas, and expertise into new products and processes. At a much later date, the late 1980s, the first concept of science parks appeared in South Korea and Brazil.

The regional impact of these parks, and the industrial activities located in them, is significant. The prime objective of science parks is to offer the most favourable

location in which new developments can be undertaken, either by new companies or by divisions of existing firms. But often, rather than being a potent instrument to ameliorate social and economic conditions of work and growth, parks are perceived as an effective conveyor of free enterprise liberal ideas particular, in the case of Britain, to the Thatcher era:

> "The least tangible, but possibly the most important benefit [of the park] is the perception given to the public, both lay and industrial by the presence of a park. It can be seen as a concrete example of faith in the future and in local expertise and enterprise." (Dalton, 1987:23).

Parks do favour a greater interaction between university and industry. They are meant for the development of knowledge-based industries and, to an extent, they are more conducive environments for innovation, technological transfer, and development than the previous model based on EPZs. Parks also differ from EPZs in their relationship with governments. In Europe, national governments both individually and collectively have been extolling the virtues of new business creation. In the UK investments in science parks have been made without the intervention of central government, being fully supported by local initiative. The motivations for such local initiatives may vary, as they do in reality from park to park. The relation with a local business, social, or political community link the park to local issues and problems rather than tie them to the international business strategies of TNCs (as in the case of the EPZs) or subject them to cuts in federal government spending such as sectoral subsidies given to particular industries.

In short, the experience to date in the UK (Dalton, 1987), continental Europe (Lafitte, 1987) and the USA (Money, 1987) shows an array of possibilities for the creation and development of parks. Individual country reports demonstrate that the experience is successful, and cross comparative examination offered by the International Science Parks Association help the spread of ideas to develop these enterprises more successfully.

The success of parks in helping the de-industrialization crisis in Europe, attracted attention from Latin America and East Asia which were also trying to find more effective ways to narrow the social, economic and technological gaps between haves and have nots. Thus the idea of the science park, in Latin America, was developed to fit a particular context of development bottlenecks, as argued by one observer:

> "The appearance of science parks in Latin America occurs in the context of on-going deep political, economic and social changes characterized by the exhaustion of a development model based on import substitution and subsidized manufacturing for export. The saturation of this model calls for a restructuring of society and economy with the introduction of new technologies to modernize the economy and equipment, to make them internationally competitive." (Pereira et al, 1987:3).

Policy markers see in the science park concept a multiplicity of agents and the dynamic profile of the enterprise inducing economic and regional development based on the generation of new technologies. These ideas do not always match reality.

If the performance of science parks is difficult to measure in an European context, similar experiments in Latin America and East Asia have to be looked at qualitatively, due to an almost total absence of any useful quantitative data. Chapter Seven examines the Brazilian experience and how effectively science parks contribute to attract knowledge-based industries, universities and a community to generate new firms, exchange ideas, development processes and products and ultimately aid in the process of regional and industrial development.

3.7 Summary & Conclusions

This chapter has dealt with the experience of NICs in developing national informatics industries. First, it looked at the position of NICs in the international division of labour. Second, summarizing national policies designed to support the development of national industries in these countries and following different classifications, the chapter has focused on the first-tier Asian NICs and on the first-tier Latin American NICs, both regions with a well developed production capacity in informatics and other sectors of the electronics complex. Third, it looked at issues related to technology transfer, employment and regional development in these areas.

This conclusion summarizes the main findings of the chapter and compares and contrasts the experience of these selected NICs against the experiences of the AICs discussed in Chapter two above.

It has been demonstrated in these two chapters that there is a clear division between AICs/NICs with respect to their industrialization and overall development. Economies in the AICs have a longer history of industrial development with internationally strong and competitive capital goods industries. The development of the electronics and informatics industries in these countries benefitted from the existence of

a solid industrial foundation with producers of components and suppliers, support services (equipment repair, maintenance), and well-established subcontracting networks between producers and markets. It has been shown in Chapter two, however, that the AICs are not an homogeneous block of countries but a mosaic of developed and less developed regions where intra-regional differences are substantial (Chapter two, section 2.5).

In informatics, TNCs originating in the United States, Japan and Europe control product markets and technologies, and have exported these technologies and products to all developing countries. These TNCs have benefitted from an early process of internationalization of their productive structures and are now present in almost all informatics producing and consumer markets worldwide. NICs, on the other hand, as we have seen, are still overwhelmingly dependent on generic technologies and product standards originated in the AICs.

The NICs, in turn, share common characteristics of latecomer industrialization including very fast industrialization histories of less than 40 years. As a result, more fully developed industrial foundations are needed for an orchestrated development of national informatics industries. In the quest of developing whole national industrial sectors, NICs have suffered from small (first-tier Asian NICs) or ineffective/disorganized (second-tier Asian and Latin American NICs) capital goods industries (as in the case of first-tier Latin American NICs) which are important suppliers and consumers of informatics. As a result, other important industrial and social linkages (suppliers, support services, subcontracting relations, skilled labour, S&T) are poorly developed or absent (Ernst & O'Connor, 1989).

In spite of late industrialization and partial development of an industrial base, of a well developed international industrial complex, and of the oligopolistic structures of TNCs and dependency on foreign technologies, it has been shown in this chapter that many NICs have managed to develop national informatics industries.

These relatively recent developments, (most informatics industries in the NICs have been around for less than 20 years), challenge propositions put forth by dependency theorists that the Third World and NICs function as suppliers of cheap inputs (raw materials and low valued added manufactured goods) and markets for the AICs. Also, as discussed in Chapter two, the experience of the AICs with electronics and informatics have started and developed as a response to internal needs for new systems

to collect, store and process information and from competition between these countries (US, Japan and Europe) independently from events taking place in the rest of the world. The very complex processes leading to the development of informatics as an industrial sector in many parts of the developed and developing world call for a theoretical framework that recognizes the role of other agents in the development process which dependency theory cannot provide. This point is discussed again later.

The role of the state is an important theme permeating the discussions of AICs and NICs. Chapter two demonstrated that the state has had a distinct and explicit participation in the development of electronics and informatics industries in all three country/regional cases studied. From a very explicit form of state intervention characteristic of developments in Japan, France and at a later date the European Community, to a lesser involvement of the state in the case of the United States and Great Britain, the history of informatics cannot be told excluding the political concerns in the countries involved. State role in the AICs has been both active (United States in the 1950s and 1960s, Japan in the 1980s) and responsive to strategies being developed by competitors (France in the 1970s, the EEC in the 1980s).

The participation of the state in the development of informatics industries in the developing world is no different. As demonstrated above, countries in Latin America and Asia have designed policies to promote the development of national industries. Policies range in varying degrees from extremes of protectionism to liberalization, and have been used as a valve to respond to both external movements (TNC movements and strategies, technological trajectories, regional political alliances), and internal needs (rising demands for informatics goods, strategic concerns, poorly developed industrial structures, lack of skilled labour). However, the involvement of the state as an industrial policy-maker in many NICs is in response to aggressive marketing strategies of leading TNCs, and as a means to break the oligopolistic structure of the world informatics industry. As shown in this chapter, it is clear that those policies that have been most sensitive to the international structure of the industry worldwide, and to continuous changes in technology and markets have managed more successfully to achieve degrees of independence and autonomy (as it is the case for first-tier Asian NICs).

Regulation theory is useful for understanding the role of the state as a key agent in the development process. Regulation framework also looks at other criteria (labour force, national S&T structure, structure of the demand for industrial products, industrial

linkages, subcontracting networks, international competitiveness, etc) providing a focus which has been practically absent from theories of capital internationalization (NIDL). The result of state intervention in the development of informatics industries in the NICs are mixed.

Section 3.2 looked at the position of NICs in the international division of labour of the informatics industry. Comparisons are difficult and made even more challenging given the limited available data on the subject. NICs continue to play a relatively small role as producers of informatics goods. First-tier Asian NICs and Mexico have developed to become important producers of low value added parts, components and finished products to be sold in the international markets. Much of the production is linked to TNCs international divisions of labour (branch plants, subcontracting networks) rather than national firms.

NICs are an important and growing market for informatics goods. In many parts of the world (amongst least developed economies and second- and third-tier NICs) the public sector continue to be the most important consumer for these new equipment and systems. In countries with more developed capital goods and services industries, informatics is increasingly being introduced to modernize, restructure and optimize production processes and services (section 3.2.1 above).

With respect to industrial policy, the experience of the NICs covers a wide spectrum from import substitution led to export promotion led developments encompassing tight market protection (Brazil) to less regulated domestic markets (Argentina), and different graduations of export led promotion for the first- and second-tier Asian NICs (section 3.3 above).

Countries in South-East Asia have opted for an articulation with the global industry based on export promotion which has been described in terms of a two step system. In the first step these countries started their activities in informatics by turning themselves into assembly platforms to leading TNCs (cheap labour comparative advantage). At a second stage, they gained some expertise in selected aspects of production and later on, the mastering of certain technologies (Henderson, 1989).

The NIDL theory explains these developments in South-East Asia and to some extent those in Latin America, as a result of capital internationalization initiated in the 1970s in the AICs, and based on the search for cheaper labour costs as well as for new profit opportunities outside the AICs. Investors (TNCs) found in most of these countries

the necessary social and political conditions they needed to solve the bottlenecks of growth emerging in the late 1970s, and they did so with a great deal of success (see Chapter Two, section 2.3 above).

Until very recently, capital investments in East Asia were and still are overwhelmingly directed towards the production for US markets (UNCTC: 1986). This is illustrated by the flow of exports coming out of SE Asia into the United States (US$5,200m in 1982). Singapore, Taiwan and South Korea accounted for US$1,312m, US$2,453m and US$1,517m respectively).

Mexico is also an important producer for American markets, a process that has been aided by geographical proximity to the United States and, more recently, by new developments in the North American region to include Mexico in a common northern market. In 1987, 85% of Mexico's exports were microcomputers sold by IBM and HP (Fadul, 1987:225).

In the case of the first-tier Latin American NICs the situation is different. The arrival of TNC branch plants was primarily aimed at enlarging regional markets of US based corporations. TNCs activities in these markets are restricted to larger sectors of the computer markets (mainframes), which are significant (40% in Brazil and 62% in Argentina), and more sophisticated peripherals and communication devices where indigenous producers have not the technology and/or production capacity to operate (Cline, 1987).

The trajectory of a NIC from an initial position of assembly platform of parts of electronics products to one of world producer of informatics goods is not linear and, is not accessible to all countries. For the past 20 years of development of national industries a complex regional division of labour has emerged between countries in South-East Asia. These regional divisions of labour, like those that have already emerged inside Europe and even inside the United States, are quite uneven as illustrated by Henderson

> " a distinct regional division of labour has now emerged with its own (albeit crudely defined) 'cores' and 'peripheries'. The emergence of these cores has not been associated with their supplies of cheap manual labour, but if anything, with their increasing ability to provide good quality engineering and technical labour, with the development (in some though not all cases) of their own production complexes, and finally, with particular forms of state intervention." (Henderson, 1989:49).

The transition from assembly platform to a strategy of gaining greater control

of the development and production process described in the experiences of South Korea, Taiwan, Hong Kong has unquestionably been associated with the promotion of programmes to raise the skills of national human resources and to alter a comparative advantage of these countries initially based on cheap low skilled labour.

While these regional divisions of labour are often associated with different productive structures and markets, there are distinct levels of social unevenness inside the factories and offices producing and using new computer and other informatics technologies. These inequalities are much harder to pinpoint, they refer to what Smith has described as shifts in the detailed divisions of labour inside factories and work places as a result of the introduction of new production processes, new forms of organization and marketing. To address some of these differences I looked at technology transfer and changes in the labour market in the informatics industries in the NICs.

The main findings of these two sections (also based on limited available data) disclose different levels of unevenness between the experiences of the NICs and AICs and between different NICs. With respect to the first theme technology transfer, NICs are still heavily dependent on generic technologies developed in the AICs to start and develop their productive structures. The channels used for technology acquisition and the ability of individual countries to absorb new technologies vary over time within countries. These have included FDI, OEM contracts, licensing, reverse engineering and others. Many countries have managed to develop internationally competitive industries producing and marketing standard technologies. Success cases of indigenous developments exist but are quite limited. NICs still face very high barriers to developing indigenous technologies and these are likely to increase with the growing concentration of R&D inside the AICs under new schemes of industrial collaboration described in Chapter two above (section 2.5.1). Programmes of technology transfer cannot be dissociated from support of national S&T and R&D programmes, labour training and labour skill development.

The transition from the first stages of industrial development of the informatics sector to more advanced ones have been paralleled by qualitative changes in labour skills and employment throughout the developing world. Section 3.5 described how employment trends characteristic of the AICs have manifested themselves in the NICs. Selected countries have managed to move one step further in the skill levels of their national labour forces. With this asset in hand these countries are better prepared to

bargain with TNCs to attract industrial investments. As for providing for the development of human and scientific resources, differences in government and financial support reveal that most NICs to a certain extent have failed to devote the necessary attention and resources to developing and strengthening national S&T capacities, to fostering R&D in universities and industries and to raising the quality of education. The existence of a solid army of researchers, technicians, engineers and scientists are directly related to a country's technology absorptive capacity. A highly skilled labour force helps countries move from industrial activities based on labour intensive, low value-added, task-oriented assembly production. It is no surprise therefore, that countries which have managed to develop and commercialize higher value added products are also those with higher numbers of scientists and engineers (first-tier Asian NICs).

The last part of this chapter has dealt with regional development and informatics. This section also followed a discussion initiated in Chapter two about the experience of the AICs with regional development policies linked to or having an impact on electronics.

NICs share with the AICs experiences of the development of EPZs and the more recent version of regional industrial development based on science parks. The EPZ have served and benefitted TNCs by offering these companies a convenient environment (abundant labour supply, security, proximity to ports) to carry out their operations. They have not, however, contributed to successful and sustainable regional development in many NICs.

The science park approach is a more recent AICs-based experiment which for the last ten years has attracted the attention of regional policy makers in many developing countries. Most initiatives to develop science parks in the NICs have not gone beyond the planning stage and therefore cannot be fully evaluated. Very little has been done in support of industrial collaboration and cooperation amongst NICs. Experiences to date are limited and reduced to events organized by international organizations fostering South-South exchanges (Beer-Gabel & Conquy, 1984).

To conclude, the experience of the NICs in developing national informatics industries is extensive. Over 15 countries have designed some form of production and market-related policy to support these national initiatives. The results, it has been shown in this chapter, are mixed. Complex regional divisions of labour have emerged both inside and between Latin America and Asia. The shape of industrial structures, production organization, technology and labour markets are diverse and quite uneven.

The next four chapters take up many of the points raised so far to examine the development of the Brazilian informatics industry, and these will be later brought together in Chapter eight.

CHAPTER IV

IV Brazilian Informatics: Development of what? Development for whom?

4.1 Introduction

Article 2: The objective of the national informatics policy is the development of a national capability in informatics activities to the benefit of the social, cultural, political, technological and economic development of the Brazilian society.

Chapters four to seven focus on the Brazilian informatics industry. These chapters complement the analyses of global industrial development processes occurring in the AICs (Chapter two) and in the NICs (Chapter three), to focus here on the national level.

The in-depth study of the Brazilian experience is based on secondary and primary sources collected during three years of research (late 1986 to late 1989) and field work carried out in Brazil on two occasions in 1987/88 and in 1989.

Following a structure used in the previous two chapters, this analysis starts with a review of Brazilian industrialization from the early 1930s to the present. It then examines the national informatics policy, paying particular attention to the role of the state, the support given by the state to other sectors of the electronics complex and to science and technology programmes in the country (Chapter four).

Chapter five looks at the structure and performance of the national industry, focusing on sales, employment and computer installations. Particular attention is paid to the case of electronic banking. The chapter also examines the position of Brazil in the industry's international division of labour, looking at legal and illicit import and export flows.

Chapters six and seven focus on the empirical research carried out in the field to examine the relationships between producers and consumers of informatics goods and services in selected parts of the country. This study aims to reveal different levels of social and spatial unevenness inside the national territory.

Together these four chapters substantiate the arguments put forth in this thesis about the links between the Brazilian industry and the global one, the need for the state to formulate policies which support the informatics industries internationally, and the different stages of development or underdevelopment of the national industry throughout the country.

The national industry referred to here includes both Brazilian owned, (domestic companies) and Brazilian based TNC subsidiaries, producing computers, parts and peripherals.

Chapters two and three demonstrated that the oligopolistic structure of the world informatics industry has forced developing countries to seek ways to integrate their national industries with AICs based industries. A successful articulation of developing countries' needs for informatics with the world industry determines the ability of national industries to benefit from technical developments occurring where leading corporations are, and the extent of their inclusion in and/or partial exclusion from the industry's international division of labour (Delapierre & Zimmermann, 1986:111). Given the increasingly transnationalized structure of informatics total exclusion (or the notion of industrial self-sufficiency) is practically impossible.

From a theoretical point of view, the possibilities of a successful social, economic and political development of Third World countries vary. For the proponents of dependency theory, development is essentially truncated and even ultimately impossible, as AICs depend on the existence of less developed countries to supply them with raw materials (Chapter one, section 1.2). The proponents of the NIDL theory associate the intensification of capital flows into the Third World as a way out of underdevelopment, drawing data from the international movement of electronics and textiles industries to prove their thesis (Chapter one, section 1.3.2). According to the NIDL thesis these patterns of capital internationalization revolutionized development in many parts of the world. The world wide crisis of Fordism which lasted over ten years from the early 1970s to the 1980s (Scott & Storper, 1986), questioned the sustainability of development in many parts of the world including Europe and the United States. Regulation theory's greatest strength is to focus on the role of the state as an actor and regulator of the development process. This theory offers an adequate framework to examine a complex web of regional divisions of labour between and within AICs and NICs' informatics industries. The Brazilian initiative is analyzed within the framework of regulation theory, looking at historical regularities and national accumulation strategies.

4.1.1 Structure of the Chapter

This chapter focuses on the policies designed to support this industry. It begins

with a historical review of Brazilian industrialization (section 4.2.1), and of the battle between diverging political forces within the government (section 4.2.2) to provide the contextual background to explain (section 4.2.3) and critique (section 4.2.3.1) the national informatics policy - *Política Nacional de Informática* (hereafter PNI).

The political and industrial bottlenecks of the Brazilian initiative include, among other things, a conceptualization of the electronic complex that is fragmented, i.e. different policies (or no policy) for each sector of the complex (section 4.3), and insufficient and often inadequate national support for science and technology (hereafter S&T) in the country (section 4.4). Section 4.5 summarizes the main points of the chapter and concludes by looking at key aspects of the policy and the national support given to this sector.

4.2 Development of Brazilian Informatics

4.2.1 Brazilian Industrialization: The Articulation of Strategies

The informatics model developed by different coalition groups inside and outside the government fits into a broader context of Brazilian industrialization, and is very similar to other industrialization strategies pursued in Brazil.

To a large extent Brazil's social and economic structures are a result of state-led industrialization programmes employed from the 1920s onward. These uneven layers of social and economic development shaped the possibilities and constraints for the success of individual industrial policies such as the national informatics policy.

State-led industrialization programmes, like the one developed to support informatics, have been used in Brazil for the past 50 years. For the most part, and independent of the typology used to define models, development approaches in Brazil have favoured a growth path oriented from top to bottom where investments are made in key infrastructure and geographical areas, which are expected to cause a surge of backward and forwards linkages to promote the growth of other industries, services, and therefore regions.

Brazilian industrialization began in the 1930s after the 1929 crash, the world's first over-production crisis. The crash revealed the fragility of the country's agricultural based economy and made industry appear an attractive sector for investment. At the same time the government made its first attempts to design a national

industrial policy (Suzigan, 1978).

Industrialization which started with the First Vargas Presidency (1930 to 1945) was characterized by growth oriented economic development.[1] Industrialization during this period aimed to develop a capital intensive consumer goods industry in a country that was also heavily dependent on the imports of capital and intermediate goods from foreign subsidiaries of multinational corporations located in Brazil (Cano, 1985).

Government actions included the application of a wide range of fiscal and monetary policies to lure potential capital investments. These included, for example, the reduction of custom tariffs, exchange rate systems to favour imports of basic goods and raw materials, exchange rate benefits to foreign capital, public financing of selected projects, regional fiscal incentives, etc (Suzigan, 1978). TNCs benefitted the most, finding the country's development programme sympathetic to their expansionist movements.

From a technology[2] point of view, the immediate outcome of this industrialization approach amounted to a limited transfer of technology, little support and emphasis to the development of a national skilled labour force, and a restricted jobs creation plan to absorb a rising national population.[3] In the long run this emphasis on the development of a capital goods industry had an instrumental role to play in the creation of markets for computers and other information systems and as suppliers of parts and components for the informatics industries. Less than two decades into the growth oriented development plan, *Brazil became a net exporter of TNCs profits.*

An import substitution industrialization model (hereafter ISI) dominated Brazilian industrialization programmes from the mid 1940s to the mid 1960s. After this, the bottlenecks of the system undermined its reproduction. The Brazilian economy went through a recession and inflationary flights never before experienced. Figures 4.1 and 4.2 illustrate the fluctuation of the GNP and inflation rates over a 50 year period. They reveal two big slumps of the economy, one just prior to the military takeover in 1964,

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[1] in "Brazil Survey" ***The Economist*** 25/04/87. Getúlio Vargas governed Brazil twice. First was from 1930 to 1945, followed by the second presidency from 1950 to 1954.

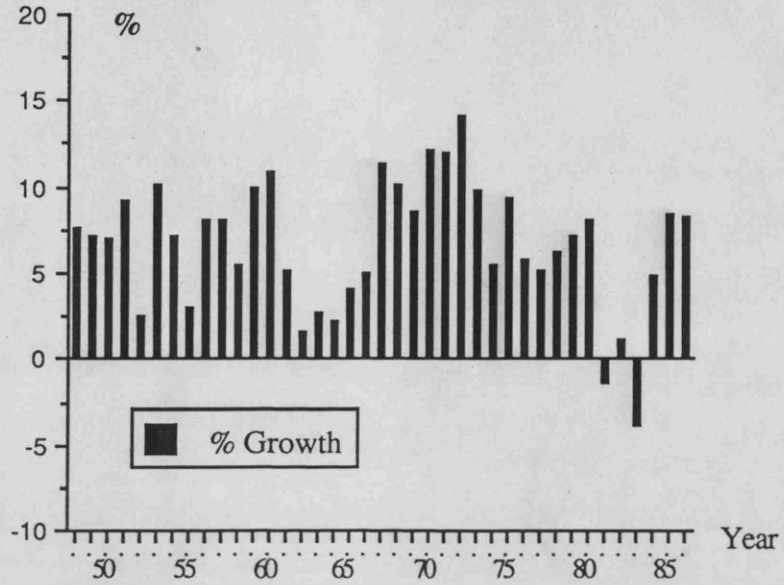
[2] The definition of technology used in this thesis is provided in Chapter 3:113.

[3] In 1940 the Brazilian population was 40 million. Twenty years later it was 70 million. "Brazil Survey" ***The Economist*** 25/04/87:5

and the other coinciding with the second oil crisis in 1979. Since then the country has experienced a succession of crises (Barros de Castro & De Souza, 1985). The more recent period of economic distress will eventually undermine some of the successes of the national policy.

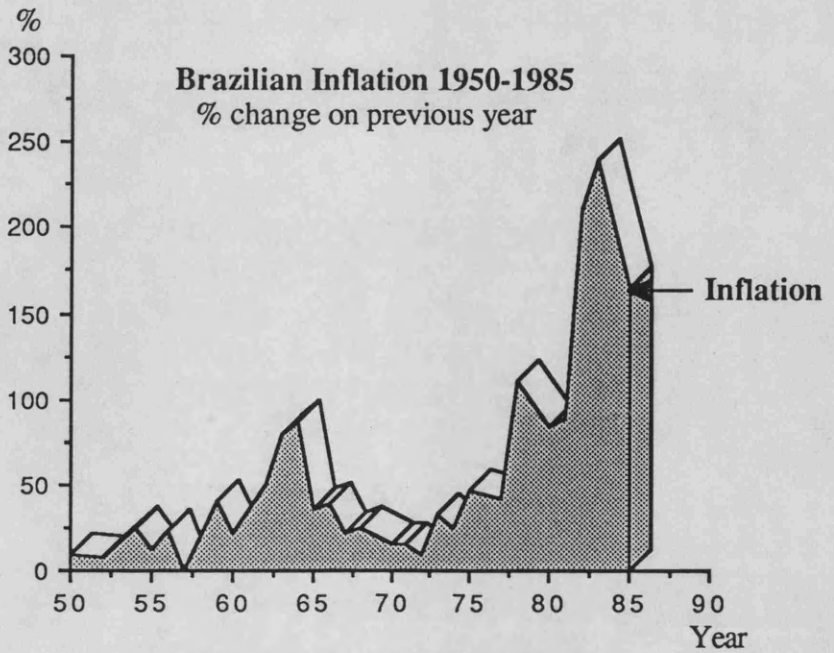
Figure 4.1

National GNP 1948 - 1987



Source: The Economist, "Brazil Survey" 25/04/87

Figure 4.2



Source: The Economist, "Brazil Survey" 25/04/87

The early 1960s were also marked by a radical change on the political agenda, a civil government gave way to a military one, with the support of the middle class. Under a military government, the armed forces openly participated in the country's industrialization process by making explicit their preferences over where to allocate national resources. The new government's development programme emphasized new investments, expansion and recovery of an industrial capacity, and the expectation that economic growth would trickle down to lower sectors of the economy and society.

The outcome was a broadening of the industrialization process into intermediate and capital goods, and a new wave of foreign direct investment that came in to profit from Brazil's competitive advantages. In 1983 the country received 17% of the total stock of FDI (foreign direct investments) in the developing economies, as compared with Mexico (10%), Singapore (6%) and Indonesia (5%). 48% of this FDI came from companies located in the USA, 13% in the Netherlands, 11% in the UK, and 9% in West Germany (World Bank, 1987:117).

Production was geared to external markets, enhancing a dependency on foreign suppliers and buyers at the expense of less profitable industries. National capitals, that in the previous model had their activities consolidated and whose interests then coincided with the activities of leading industrial sectors, were given the same support as Brazilian based foreign companies.

From 1967 to the mid 1970s a new export oriented industrialization model (hereafter EPI), replaced economic stagnation with economic boom: this period was known as the Brazilian miracle. From 1967 to 1973 Brazilian industry grew at an average of 13.4% year. The country's exports expanded 27.8% average yearly growth from 1969 to 1973, see figure 4.1 above (The Economist, 25/04/87). In the domestic terrain, supply (plenty of fixed capital and an industry with idle capacity) and demand forces (fiscal and monetary policy, expansion of credit lines for the purchase of consumer durables) boosted the economy. At a world level, the economy experienced a period of growth with a rise in foreign trade, and notably a rise of international liquidity from oil revenues. This last aspect enlarged the circulation of financial capital from oil producing countries to major world financial centres and on to the NICs. *After 1974, Brazil became a net importer of financial capital.*

As with the ISI, EPI strategies had concrete limitations. The bottlenecks of the top to bottom approach to the social, economic and political development of Brazilian

society became evident as economic trickle-down effects never materialized.

ISI and EPI unquestionably contributed to accentuate and deepen Brazilian industrialization through a greater concentration of wealth around selected industrial sectors, and located in the traditional growth centres in the south east. At the same time it also magnified regional imbalances inherited from the colonial period through a steady growth of Brazilian population and their continuous concentration in selected areas of the national territory.[1] Problems of uneven development accrued. Regional development agencies such as *Sudene, Sudeco, Sudesul and Sudam* were set up to tackle historically created regional discrepancies. These served to legitimate military interests across different areas and national regions. They also seemed to separate the country's regions giving them different strategic spatial values.

The so called high technology industries emerged in a period of worldwide economic instability, however, in spite of the geo-historic conditions, they have developed with some success.

The current economic period is characterized by a series of localized crises and booms worldwide, which, as indicated in Chapter two, suggest that the world economy is in transition to a new regime of accumulation, one with its own particular configuration, and which will have distinct potential effects on national and regional economies (Harvey, 1989; Lipietz, 1985; Scott & Storper, 1986).

Chapter two described the main features of these new realities of capitalism (Chapter two, section 2.2), and some of the strategies available to AIC based industries to cope with an increasingly complex process of accumulation (e.g., industrial collaboration, section 2.5). Chapter three described the situation of NICs based industries, where the opportunities for successful participation in the international division of labour are even more demanding and complex.

Brazil's economic situation in the late 1970s was characterized by moderate industrial growth as compared with the years of the miracle. The average annual growth rate for manufacturing between 1976 and 1980 was 6.1%, with the capital goods sector growing 2.6% per year, and durable consumer goods growing at 11.6% per year. In 1981 the economy went into a recession, with an average negative growth rate of -

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[1] By 1970 the SE region of Brazil (which occupies 10% of the national territory and includes four states of the Federation) housed 40 million residents.

5.9% per year (Hewitt, 1988:53).

In addition, Brazilian industrial competitiveness was, and still is, a result of very low wages, an over exploitation of natural resources (e.g., energy), and an excessive subsidy for exports (which are vital for the repayment of the external debt), and not a result of a modern and productive industrial complex (Suzigan, 1989). *In the 1980s, and probably most of the 1990s, the country is a net exporter of financial capital.* It is within this context that the national informatics industry has developed.

4.2.2 State and Military Roles in the Formulation of the National Informatics Policy

The Brazilian informatics industry began to develop with the support of the state, the military and of a national capitalist class. The National Informatics Policy and the institutions the state created are not extraordinary in Brazilian history.

The purpose of this section is to review the model to demonstrate that, on one hand, the PNI is part of the country's policy tradition; and on the other, it has been organized according to the interests and ideologies of its promoters, producers and professionals (Schwartzman, 1985).

Brazil has the oldest informatics policy in South America. In the early 1970s, the local industry was restricted to import activity of TNCs subsidiaries located in the country. Some equipment was assembled locally, but there was no local involvement in the production of data processing equipment.

Demands for the modernization of Brazilian military machinery, the desire of aspiring Brazilian capitalists to use the nation's engineering skills, and a rising public sector demand for informatics equipment contributed to the formulation of the policy (Evans, 1986:753).

In the late 1960s, the navy purchased six British frigates equipped with what was then state-of-the-art electronics navigation equipment. Fearful of a possible dependence on the British manufacturer, Ferranti, for technical support in operating and maintaining the machines, the navy insisted on sponsoring a project to develop a national technical capacity in electronics (Piragibe, 1985:117). Military interests converged with the intentions of the National Economic Development Bank (hereafter BNDES) to stimulate technological self-sufficiency in the Brazilian industry. The Navy created a special working group, hereafter named GTE, to formulate a plan for the creation of a national

computer industry. The Ministry of Planning, in turn, also set up its own agency in April 1972, CAPRE, the predecessor of SEI, in charge of the rationalization of computer purchases, the inventory of existing computer equipment in the country, the financing of data processing activities, and the training of technical personnel.[1]

Concurrent to military developments, electronics engineers were emerging from national universities. Opportunities were available for some to leave the country to complete their training in American institutions, and for others, to work as sales persons for IBM or Burroughs (Dantas, V, 1988:32). Many of these were later to become key figures in the defence of national capitalist interests.

In the early 1970s, these engineers developed and built a computer prototype and other digital equipment. The first Brazilian computer (the Patinho feio) was built in the Digital Science Laboratory of the University of São Paulo's Polytechnic School. The project took two years to complete (July 1972). The machine had a memory capacity of 4K (Dantas, V, 1988:52).

Indigenous technological development did not stop with the computer prototype. Researchers at the Institute of Applied Economic Planning (IPEA) designed a special software system to read and reject incorrect census data, and the Special Projects Group of the National Data Processing Centre (SERPRO) developed a data communication unit with 32 monitors and interface boards to input the inland revenue data (Dantas, V, 1988:62).

These products however were simply not manufacturable in Brazil. Local producers, that is TNCs subsidiaries located in the country, were not interested in converting local developments into commercial products but preferred to produce and distribute their own. This strategy pursued by Brazilian based TNCs was similar to the operations of other TNCs located elsewhere in the NICs, as described in Chapter two (section 2.3, and table 2.1).

The third element of pressure came from a growing public demand for data processing equipment. Prior to the informatics law, the supply of those demands were met mainly with imports of systems produced by leading TNCs. In 1965 there were 89 installed systems in the country 2/3 of which were IBM, followed by UNIVAC, Burroughs, NCR and two from Bull. By 1969 there was already a demand for

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[1] Decree No. 70.370 of 08/04/1972.

informatics goods in Brazil which rose 27.9% a year between 1969 and 1981 (SEI, 1982). As there was no local production, by 1974 informatics goods valued at US$ 94 million, were third on the import list, surpassed only by airplanes and heavy agricultural tractors (Tigre, 1978:121). From 1973 to 1978, the national foreign debt went from US$5.8 to US$31.6 billion. This increase forced the reduction of the country's imports, including that of informatics goods.

The demands of these three interested groups culminated in the announcement of two general recommendations. In the civil sphere, it was recommended that a production oriented policy be formulated to coordinate the creation of a national informatics industry, including the creation of a national computer firm. In the military sphere, the group recommended the support of a research programme to build a computer and the necessary software to be used in naval operations, also known as *Projeto Guaranys*, to be financially supported by the FNDCT/Finep and Funtec/BNDES (Piragibe, 1985:118).

The company was to be set up through the association of the government, a local firm and a foreign manufacturer. The idea was at first difficult to implement. Major TNCs were not interested in sharing their technology with a company in which they would have only a minor control, nor was local capital enthusiastic about the idea of sharing triangular business arrangements, that is an association of state, national capital and foreign capital (Evans, 1986:793). It is worth mentioning, however, that the creation of companies owned and run as part of the state's administration has been a constant feature in the country's approach to industrialization (e.g., *Volta Redonda* 's steel mill in the 1940s and *Petrobrás* in the 1950s) (Schwartzman, 1985:3).

Cobra, the national state company created in 1974 was the outcome of a *tripe´* (three way) arrangement between *Digibrás* (the state owned holding, in turn, owned by BNDES), EE *Equipamentos Eletronicos* (a small electronics components firm) and Ferranti, the British manufacturer.

Cobra was to play a leading role in the national effort to develop technologies, to form and train a capable labour force, to develop products and processes and, ultimately, to prove to Brazilian capitalists and other interested groups that it was technically possible to produce informatics goods in the country. At the outset of its operations, the company encountered innumerable difficulties. *Cobra*'s first licensed product was an already obsolete Ferranti computer, the *Argus 700*, sold as C-700 which

proved inadequate and difficult to sell in the Brazilian market (Evans, 1986:793). As a state company, *Cobra* also developed the government's G-10 computer prototype project into a commercial product, the minicomputer C-500. This investment was a success. Sales of the C-500 consolidated the company's role in the industry (Tigre, 1987).

Opposition to the national informatics development plan came from both within and outside the state structure. Within the state apparatus the dispute between the Ministry of Science and Technology (MCT) and the Ministry of Communications (MINICOM), heated up in 1985 over differing views on policy.

MINICOM refused to separate the electronic data transmission activities from the non electronic ones, undermining SEI's responsibility for the entire national automation policy. MINICOM defended an alternative national informatics policy that stood halfway between total market freedom and total autonomy. Moreover, it condemned SEI for prohibiting IBM from producing its system 32 in Brazil, for having lost the production of HP's 3000 machines to Mexico, and for having paralysed the microelectronics activities of Motorola and Philco (Gazeta Mercantil, 16/07/85).

These political differences contributed to the fragmentation of the desired integrated of policy, and still affect present day initiatives to bring together diverging points of view inside the state structure.

From outside the state, opposition to the policy came from TNCs located in Brazil, such as IBM. In 1979 the firm tried to launch its system 32 minicomputers in Brazil. The proposal, based on an import substitution industrialization scheme, went against policy restrictions on TNCs business in the mini and micro computer sector. IBM's proposition was rejected and replaced by independent proposals from Brazilian firms. The pattern of the conflict appeared to be one where IBM tried to inflict a worldwide logic on the Brazilian political and industrial fabric, open it to the international market, and place the country in the company's international division of labour.

Despite the obstacles hindering the formulation of a national informatics policy, electronics was becoming more and more important within the military. As a result with the support of the armed forces CAPRE was closed and substituted by a new agency in 1979 - the Special Informatics Secretariat, under the National Security Council.[1]

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[1] For a detailed account on the political development of the national policy see Dantas, V. (1988)

Prior to the democratization process, the agency could and did "interfere in all branches of government having to do with data processing - which means all of them" (Schwartzman, 1985:6). In 1985, SEI's authoritarian power became incompatible with the new democratic ideals of the Republic. To alleviate the situation, the agency's activities were institutionalized into a law (Brazil: National Congress, 1984; Dytz, 1987: chapter 5).

4.2.3 The National Informatics Policy

The previous section summarized some of the key features of the political battle fought to establish a national informatics policy. This section examines the policy.

The national informatics industry development model was formulated to give priority to the development of a national technological and industrial capacity in informatics and other high technology sectors. The plan also hoped to improve the strategies earlier used in the previous ISI and EPI schemes regarding the incorporation of learning aspects of technology and industrialization.[1]

The national model is a mesh of mixed developmental strategies with wide ranging implications. It is anchored on the idea that informatics is strategically important for the country and because of that, national capital ought to be able, given the necessary support, to develop and accumulate technological know-how and competitiveness in digital information processing technologies (Dytz, 1987:15).

Figure 4.3 below is a diagrammatic representation of the government's informatics industry policy. The idea is that the market reserve works to lower otherwise high entry barriers into a highly internationalized industrial complex for Brazilian owned firms that lack technology, by protecting infant Brazilian owned firms from the predatory attitude of transnational corporations whether based in Brazil or not.

The government chose the minicomputer sector to be the first one to operate under the new policy because at that time the mini systems sector was the most relevant to the demands of the Brazilian navy. But other sectors were to be developed later (Helena, 1981:83). SEI has the power to grant production licences to firms, and to oversee the distribution of products per firms and per technology areas. Without the presence of TNCs, these firms could operate in a protected market environment and,

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[1] Dantas, M. "Trabalho Qualificado é a saída para atrair investimentos" in ***Informe Abicomp***, no.27 Set. 1988. See also, Dantas, M. "Um novo desafio" in ***Informe Abicomp***, no.28 Oct/Nov.1988.

should in theory be able to compete amongst themselves, gain the necessary experience and competitiveness, expand their product and technologies to, later on, confront transnational contenders in both foreign and national markets.

In this model, technology is obtained through transfer agreements with TNCs to reduce usual market entry barriers and minimize project and production problems which firms would probably encounter if undertaking an indigenous product development themselves (Piragibe, 1985:110). Imports are also controlled by SEI and import quotas determined so as to monitor the process of import substitution and accumulation of national technical expertise in the various product areas.

The model can be compared to a type of technological/product cycle. That is as national companies move through time (arrow "A"), they achieve technical competence in a particular product (i.e. micro computers, serial printers, etc.), new ones are opened up (that is protected from foreign imports) to indigenous development (super-mini computers, hard disk drives, laser printers, etc..), until most products complete the technological migration cycle. Technology complexity increases as companies migrate through the technology cycle (represented by Arrow "C"). Protection is ultimately removed when national corporations achieve a command over their technologies and international competitiveness, and it is not enforced in the markets for mainframes where TNCs hold the largest shares. With growing utilization of digital technology in many other industrial sectors, the national informatics policy expands its market protection to encompass micro, peripherals, microelectronics and suppliers sectors, industrial automation, digital instrumentation, and most recently super minis and software.[1]

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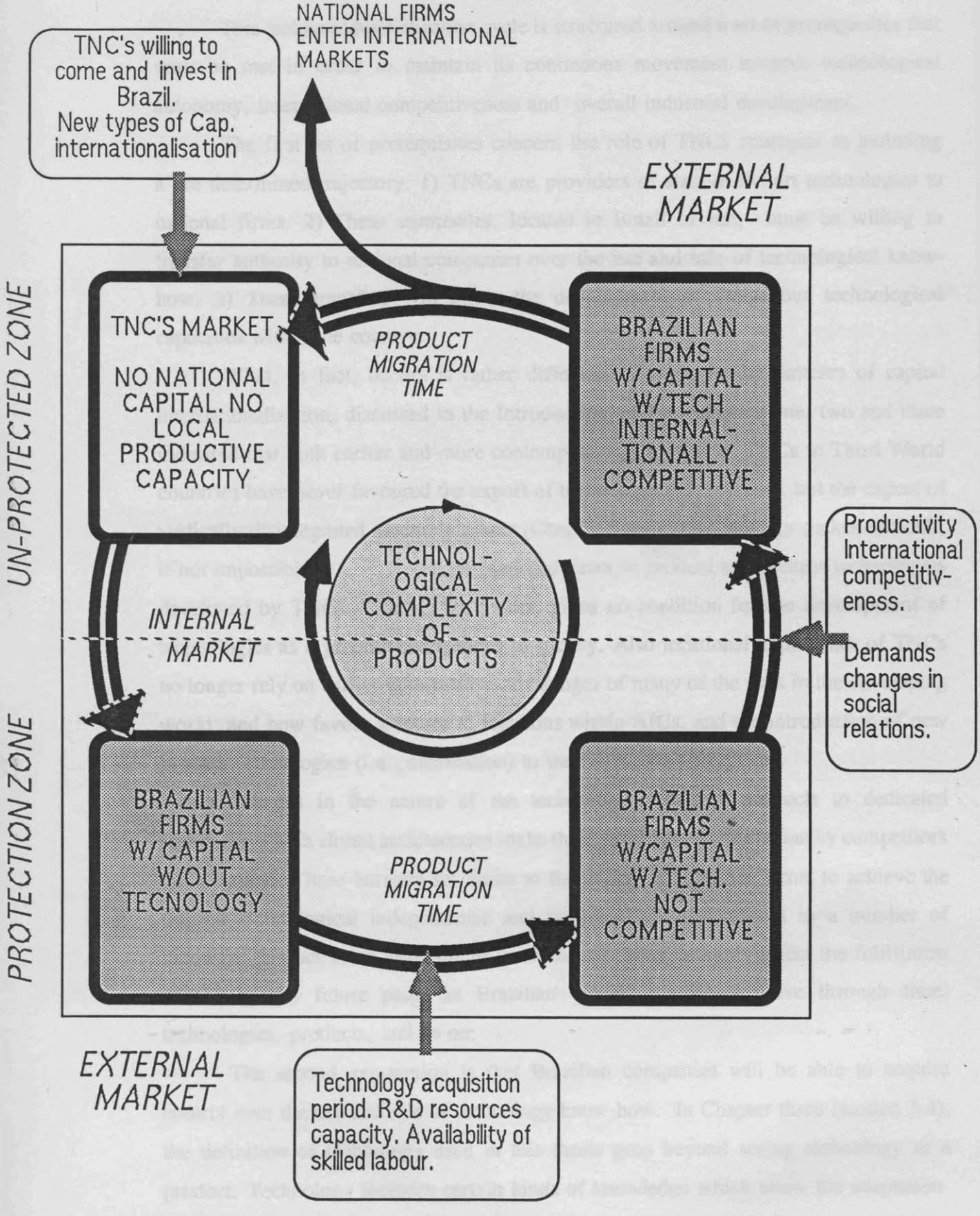
[1] ***Informe Abicomp***, no.23 May 1988 "Software law no. 7646."

Figure 4.3



TECHNO-INDUSTRIALISATION CYCLE

4.2.4 A critique of the model

This techno industrialization cycle is structured around a set of prerequisites that must be met in order to maintain its continuous movement towards technological autonomy, international competitiveness and overall industrial development.

The first set of prerequisites concern the role of TNCs strategies as including a pre determined trajectory. 1) TNCs are providers of state-of-the-art technologies to national firms. 2) These companies, located in Brazil or not, must be willing to transfer authority to national companies over the use and sale of technological know-how. 3) These transfers will allow the development of indigenous technological capacities within the country.

What, in fact, occurs is rather different. Changes in the patterns of capital internationalization, discussed in the Introduction, and in Chapters one, two and three indicated that both earlier and more contemporary migration of TNCs to Third World countries have never favoured the export of technological know-how, but the export of vertically disintegrated assembly plants (Chapter three). This strategy makes difficult, if not impossible, for national firms to absorb product and process technologies developed by TNCs. Instead, the model, gives no condition for the development of technologies as a process endogenous to society. Also locational approaches of TNCs no longer rely on earlier comparative advantages of many of the sites in the developing world, and now favour a return to locations within AICs, and the introduction of new process technologies (i.e., automation) to the NICs assembly plants.

Changes in the nature of the technologies used in products to dedicated components with closed architectures make their purchase and utilization by competitors quite limited. These barriers set limits to the ability of Brazilian firms to achieve the desired technological independence and industrial competitiveness in a number of hardware product areas available to them earlier. They certainly affect the fulfillment of the cycle's future paths as Brazilian owned companies move through time, technologies, products, and so on.

The second assumption is that Brazilian companies will be able to acquire control over the use and sale of technology know-how. In Chapter three (section 3.4), the definition of technology used in this thesis goes beyond seeing technology as a product. Technology includes certain kinds of knowledge which allow the adaptation

of means to ends. This knowledge, in turn, is embodied in machines, in technical experience/know-how/skilled labour, in organizational structures and behavior. Thus it is critical to have access to national resources to develop and expand local R&D capacity, a skilled labour force (or alternatively the resources to fund labour training, formation and re-skilling) and a commitment to develop local solutions to facilitate the arduous task of technology transfer.

Brazilian policy and Brazilian companies operating in this sector have not recognized the importance of building a solid scientific and technological base from which to develop indigenous technologies, and companies operating in the sector overlooked and played down R&D activities at the expense of 'safer' (already tested elsewhere) and more marketable products. To demonstrate this section 4.4 below reviews government support given to science and technology programmes and illustrates that policies did not meet national needs and capacity.

The third assumption is that firms achieve productivity increases and become internationally competitive in their product markets. These two suppositions touch closely on the structure and extent of the development of capitalist social relations in Brazil. There is no indication of how productivity level can be raised. Brazilian labour is poorly remunerated and productivity levels are below international levels (Suzigan, 1989:21). Between 1980 and 1987 productivity gains in the S. Paulo industry averaged 14% per year, whereas during the same period Japan experienced gains of 70.5%, 58.9% in Italy, 41.1% in Great Britain and 43.2% in the USA (USA Labour Office, in Folha de S. Paulo, 8/9/88).

Unless attention is given to introduce social innovations at the plant level such as new forms of organization of production, new worker-management relations, equipment and investments these productivity gains will not be obtained.

Brazilian firms could, nevertheless, become internationally competitive by following a strategy already used in the export sectors in the country. That is, one that relies on the low wage levels of the national labour force, which exploits local resources and receives heavy subsidies from the government to make products internationally price competitive. This strategy, needless to say, poses serious limitations to a more substantive social development at the local, community level, even if results amount to a positive balance of trade.

The model not only assumed too much about too many crucial issues but,

according to congress persons (at the time supportive of the PNI), confirmed during interviews that legislation drafted at the time of the approval of the law covering aspects of R&D and human resource development was vetoed by the president during the approval of the informatics Law in 1984. Vetoed articles included securing 0.8% of the national budget for R&D (Cz$ 960 bi in 1985), and providing resources for programmes on the impact of informatization on firms productivity.

4.2.5 Summary and Conclusions

This section examined how the informatics development strategy fits into a broader context of Brazilian industrialization. The argument made here is that the model is similar to other sectoral industrialization approaches used in the past under the import substitution and export promotion industrialization strategies.

While the PNI has been seen as innovative by devoted nationalistic supporters, the model falls short of promoting the necessary development of social factors (e.g., a labour class, skills, etc.) which are essential for a successful economic performance. This limitation is present throughout the process of Brazilian industrialization and in the country's social economic structure.

One should keep in mind, however, that industrial policies and instruments are historically determined. The Brazilian approach was developed in 1979 and institutionally approved in 1984 when technologies differed substantially from now.

Many policy reviewers, including the government itself, tend to focus on the successes so far achieved using loosely articulated criteria that refer to the state of the industry in 1979. Or as a leading government officer remarked when asked how he would evaluate the national performance: "In 1979 we had only a handful of firms and some 7 thousand salesmen working for IBM, now we have 300 firms and 50,000 jobs, isn't this enough?" [1]

From interviews and contacts carried out during field work in 1987-88 it is possible to surmise that inside the government and SEI in particular, amongst members of the industrial community, and amongst industry analysts, a feeling prevails that there is a need to improve the criteria of evaluation and assessment, a criteria that can identify real strengths and weakness of the national model and that could be applied to

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[1] Personal interviews , SEI, Brasilia, Jan. 1988.

make it more dynamic and flexible to technological, political, and market changes. The task of making the national informatics policy flexible and innovative, however, seems to be a real problem for Brazilian policy makers.

Responses given during the first round of the company survey carried out in 1987 give a mixed picture about industrialists' perception of the policy and the market protection.

Two questions focused on technology [1] and market reserve. The first question asked firms to explain how much information (if any) they had about technological developments occurring in informatics worldwide and how they got this information (e.g., magazines, trade fairs, visits abroad, licensing agreements). The second question was about their reliance on foreign technologies, and if positive, which type of technology (e.g., parts, components, software) they depended on. Firms were also asked about their opinion of PNI and in which way the policy helped or hampered their businesses.

With respect to technology, all respondents acknowledged that they were familiar with technological developments worldwide. Most recognized that their dependency on generic and proprietary technologies produced abroad obliged them to keep abreast with events occurring in the global industry. The extent to which many of these firms kept up with innovations elsewhere varied. Most mentioned the specialized literature and travel abroad as two ways to receive that information. Four firms referred to their licensing agreements with foreign producers as their vehicle to learning about new developments.

The general perception of the policy was a positive one. Many firms were formed after the policy was approved by government, and these firms could only operate under clear market protection. But, more important, firms argued that they were in the business to make a profit, the policy facilitated this profit making exercise as it removed foreign competition giving many firms the shelter they needed to operate in the sector.

Senior managers of large national companies were aware of technological

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[1] In the particular context of the letter survey I deliberately restricted the notion of technology to knowledge embodied in machines (parts, components, systems). This was done to facilitate the respondents' task and to get a higher rate of replies. More extensive discussion about technology as a process, organizational structure and behaviour was left for direct interviews and field observation.

innovations [1], and with many of the risks associated with excessive protectionism on the long term future of their enterprises. They referred to lack of competitiveness, low production scale, limited capital, poor sourcing, scarcity of trained labour, economic instability, to name a few. These survey replies were cross checked during field interviews carried out with industrialists, policy makers, industrial analysts, and researchers.

The convergence of sectors within the electronics complex is one crucial contemporary feature of the informatics sector in particular, and of the electronics complex in general (Arnold & Guy, 1986). The implications of this convergence are already felt at a world level, with a movement towards greater technological integration and multilateral cooperation in cost shared R&D programmes (Chapter two, section 2.5).

Yet, technological convergence and greater interdependence between informatics and other sectors and spheres of the socio-economic life have not, in the case of Brazil, been facilitated by an institutional convergence of the agencies in charge. As already demonstrated, their activities contain instead the frictions of a very loosely arranged national science and technology programme marked by diverging national interests and ideologies. The following section examines the organizational structure of three other sectors of the electronic complex and where their structures intersect with the informatics (computer and peripherals) production sectors.

4.3 Technological Convergence - Informatics and the Electronics Complex

In the mid 1970s, activities in the electronics complex were split both in production process and use of goods produced. Technological developments have since brought whole sectors together (e.g., the convergence of informatics and telecommunications), opened up new ones (e.g., automation, commercial, industrial and financial), and reshuffled the technological and strategic position of sectors around (e.g., the software/hardware ratio). The restructuring of the electronics complex affects the strategies of the world's industry leaders (TNCs), which in turn affect these sectors

[1] From survey responses and interviews it was clear that senior and middle managers of large national firms were familiar with the introduction of new products in world markets, and were aware of new production and process technologies such as just-in-time systems, flexible production, industrial automation, and so on.

at national levels.

The Brazilian electronics complex is very uneven both in terms of its output/employment ratios, the origin of capitals in each sector (TNCs and Brazilian capitals), product and technologies, and the policies that regulate them. Super-imposed on this unevenness at the industrial and institutional national levels is an equally heterogeneous international structure.

This section comments on the situation of telecommunications, consumer electronics and microelectronics to show key points of political friction in the national electronics complex. Table 4.1 below briefly summarizes: first, the capital structure of each sector at a world level; second, the types of articulation that exist between Brazilian and TNC capitals in the country by industrial sector; third, the origin of capital in each of the national sectors and, lastly, the nature of the industrial processes in Brazil by sector.

Table 4.1
Articulation of Brazilian Interests in Transnationalized Industries

Industry	*Type of world industry*	*Forms of capital articulation in Brazil*	*Origin of capital in the national industry*	*Production structure*
INFORMATICS	Transnational Oligopoly	Partial exclusion of national logic	40% Brazil 60% TNCs	product design assembly
TELECOM MUNICATION	State Monopolies	Partial exclusion of national logic	Mainly TNCs	assembly imports
CONSUMER ELECTRONICS	Japanese TNCs	Exclusion of national logic	Mainly TNCs. Supremacy of Japanese industrial strategies	assembly imports
MICRO ELECTRONICS	Transnational oligopoly	Exclusion of national logic	Mainly TNCs	imports
SOFTWARE	Japanese TNCs	Exclusion of national logic	National production	copy

Each sector described in the table reveals a specific structure of capital ownership in and outside Brazil. These differentiations have made the formulation of a single coordinated policy for the electronic complex a difficult, if not impossible, task. Table 4.2 gives the value of sales position of each sector vis-a-vis the whole complex, in US$ million.

Table 4.2
Gross Profit of Different Sectors of the Electronics Complex, 1980-88

Sector	*80*	*81*	*82*	*83*	*84*	*85*	*86*	*87*	*88*
Consumer Electronics *	2174	1845	2101	1903	-	-	-	-	-
Telecoms @	-	-	-	-	-	437	636	617	1004
Informatics @	860	1040	1608	1487	1728	2115	1126	2578	2465
Industrial Automation	-	-	-	-	86	101	199	294	309
Instrumentation	-	-	-	-	-	19	25	55	74
Microelectronics @	-	-	-	-	-	-	209	242	348

* Geicon, 1984 in Piragibe (1987:128)
@ Brazilian National Firms and Brazilian Based TNCs
Source: SEI (1989:13)

4.3.1 Telecommunications

From the early 1960s, the Brazilian telecommunications industry opted for a strategy with regard to TNCs which excluded potential national industrialists from participating in this sector and from developing a national digital technology capacity. The strategy was to open up to international investments in the sector. The government wanted to refurbish the national telecommunications structure to connect the entire country, and to satisfy military strategic concerns over the territorial and cultural integration of Brazil. TNCs seemed better able to undertake the task. The idea was to build a modern, efficient telecommunications infrastructure which from the start planned to adopt fully digital technology in the Brazilian systems. A state company Telebras was created and given monopolistic power over the sector. The government also set up the national research centre CPqD, linked to Telebras to undertake R&D in all major areas of digital technologies from telecommunications (Hobday, 1985:28).

Telecommunications is an important sector of the electronics complex. In contrast to the informatics case, four leading Brazilian based TNCs practically control the national market for these products (Ericsson, NEC, ITT and Siemens) (Hobday, 1985). TNCs also employ a greater number of people than Brazilian firms, even if employment in the national companies has almost tripled in the last five years. In 1984, the Brazilian owned companies employed 5,250 people. In 1988 the number rose to

13,526 (SEI, 1989). Brazilian owned firms concentrate mainly on the production of data concentrators, transputers and parts and components. The public sector is the major client (67.27% in 1987) followed by industry (13.36% in 1987) (SEI, 1989:42).

The national telecommunications base is the most developed in Latin America (Hobday, 1985). From the user's point of view, this has helped the introduction of other services within the present network, making the first steps of a convergence between telecommunications and informatics viable (e.g., the explosion of local area networks, the connection of Brazil in the Bitnet system, the intensification of electronic banking throughout the country). On the other hand, from the point of view of industry and production the antagonistic relations between informatics and telecommunications with regard to foreign capital, imports and structure of the sector's labour force, put in jeopardy not only the existing links between the two sectors but the enlargement of the national companies' share of the total Brazilian telecommunications market.

While the power of the state may have contributed to a greater participation of national capital in the sector, the dependency on the single public market raises problems any time there is a recession. In 1980, cuts in government expenditure rocked firms and threatened their position (Piragibe, 1986:129). In 1987 again, government procurement declined by 13%, causing a slump in sales of most sectors of the electronics complex. The concentration of purchases in the hands of Telebras was used to put pressure on Brazilian based TNCs to locate more manufacturing and R&D facilities in the country, and to demand greater technology transfer from these TNCs to local producers.

4.3.2 Consumer Electronics

Consumer electronics is the largest sector of the electronics complex with a market with an estimated value of US$1930 million in 1983, or 56% of the total electronics market in the country (US$3430 million) (Piragibe, 1987:128).

Baptista, in one of the best studies of this industry, describes how the television production sector has been restructured to accommodate the arrival of foreign companies and new industrial policies (Baptista, 1985). Up to 1973, the sector was controlled by national capital. There were 20 firms producing black and white television sets in the country and all firms were located in the South east. In 1972 with the change to colour broadcasting, and the government's decision to implement its regional policy

project to create a free trade zone in the Amazon (Zona Franca de Manaus, hereafter ZFM), the position of indigenous consumer electronics industry deteriorated dramatically (Baptista, 1985). By 1978, 65% of colour television sets, 85% of stereo systems and 90% of electronic calculators consumed in Brazil were produced in the ZFM. The number of television producers was reduced to eight (one national, two wholly TNCs and five joint ventures) (Baptista, 1985:23).

Leading companies in the sector (Panasonic, Mitsubishi, Semp Toshiba, Philco, Hitashi, Phillips, Sanyo, Gradiente and CCE) have, under the scheme in the Manaus import zone, enjoyed a business bonanza. In 1988, the sector sold US$3 billion worth of radio cassettes, compact disc players, colour televisions, and camcorders to a restricted group of Brazilian consumers who can afford items costing US$3500 (Semp Toshiba's latest television assembled in the country), and are prepared to buy technologies developed seven years ago (Exame, 10/10/90). This success is, however, very tenuous. The consumer electronics sector caters exclusively for the country's domestic market. Thus, any changes in the health of the national economy (as opposed to changes in the international competitive arena which regulates consumer electronics sectors throughout East Asia), can directly affect the stability of the sector. The present market focus, production structure and heavy dependency on foreign technologies of the consumer electronics sector does not aid the formation of a solid and well linked electronics complex in Brazil.

4.3.3 Microelectronics

The presence of TNCs engaged in the production of components in Brazil dates back to the 1970s when Burroughs had a assembly line to assemble integrated circuits. In 1981 two Brazilian firms (Elebra and Itaucom) obtained government permission to enter the sector. In 1982 the Centre for Informatics Technologies (hereafter CTI) was created, to develop productive activities in the sector. CTI bought the technical equipment from Burroughs to start the encapsulation, assembly and testing of integrated circuits (hereafter ICs), and began research activities to produce photographic masks from ICs (Piragibe, 1985:133). In 1986 the inter-ministerial industrial policy group decided to invest Cz$1.2 billion in R&D in informatics (including microelectronics and software) allocated to CTI between 1987 and 1989 (Folha de S. Paulo, 14/08/86:9).

Two empirical findings confirm the weakness of Brazilian activities in this

sector. Microelectronics represented 14.47% and 22.07% of the total import bill in 1985 and 1986 respectively.[1] At the same time Brazil is not a key location for TNCs assembly activities, as indicated in table 4.3.

Table 4.3
PRINCIPAL DEVELOPING COUNTRY LOCATIONS OF SEMICONDUCTOR ASSEMBLY, 1983

Country	*Value of OECD imports of semiconductors (US$mi)*
Malaysia	1066.4
Singapore	820.6
Philippines	482.1
Republic of Korea	385.1
Taiwan	359.4
Hong Kong	202.7
Mexico	145.2
Thailand	85.5
Indonesia	62.5
El Salvador	49.3
Brazil	30.7
Barbados	14.0
Total	3793.0

Source:UNCTC (1983:35)

Despite the limited participation of Brazil in the international division of labour for microelectronics, some Brazilian firms have entered the market carrying out the first steps of ICs production (assembly, burning and testing). There are 23 companies in the sector. Thirteen of these are Brazilian and 9 and subsidiaries of TNCs. Most of the these companies are located in the Manaus export zone where they benefit from import subsidies of key components which are not deemed profitable to be produced in the country. As a result the import content of microelectronics products produced in Brazil was very high (SEI, 1989).

On the demand side, semiconductors are crucial in the assembly of other

[1] "O Mercado de Bens de Informatica: Evolucao das Importacoes Autorizadas em 1985 e 1986. Volume I: Fabricantes e Fornecedores. Rio de Janeiro: Abicomp, 1988:25.

products. The consumer electronics sector uses 61% of the total volume of imported components, followed by informatics (12%) and communications (10.8%) in 1983. Informatics, in turn, consumes 52% of the total volume of imported ICs (Piragibe, 1986:130).

The ready availability of standard ICs on the market made it possible for many Brazilian firms to engage in computer production. National manufacturers of informatics goods did not see a need to develop a national capacity in the microelectronics sector, considering the ease with which these components could be imported. Also, national producers did not receive promised incentives and financial resources to enlarge their R&D capacity and activities in microelectronics.

Internationally, producers have moved to using new types of ICs, the so called ASICs with embodied manufacturer technologies, which make reverse engineering more difficult. At the same time, there is a growing competition between leading world producers of generic and proprietary ICs. Producers have increasing risks and development costs before they can launch a new product in the market.

The growing importance of microelectronics in the Brazilian industry has prompted the government to consider reformulating the national informatics policy to include the microelectronics sector (Rosenthal, 1987).

The new policy aims to create an oligopolistic structure where three companies are given total control of the sector. Itaucom, SID Microelectronica and Elebra have been chosen to lead the national plan. The import of finished components demanded by the Brazilian market will be controlled by this oligopoly as will the importation of components for their own assembly/production activities, and the commercialization of these imported and locally produced ICs in the domestic market. To facilitate this oligopoly becoming established, SEI will discourage the direct imports of components by Brazilian firms and re-direct the demand to the three national firms in control of the commercialization of ICs. Increased demand should allow the producer to achieve a needed scale to carry out their industrial activities in the area. The governments' ability to offer this new type of market protection demands in exchange from the firms themselves a commitment to invest in R&D. The usual tax subsidies are included in the package.

Hence the national microelectronics policy follows a model similar to that of the PNI. The linkages between the two will jeopardize the success of the former even

before the latter takes off. For example, the national microelectronics policy focuses, as in the previous case, on the production of IC hardware. The existing industrial activity uses imported machinery and wafers that are assembled, tested and sold in Brazil. The PNI gives no support to the production of ICs in the country. The bottlenecks created thereby have hindered the transition of Brazilian firms from production of standard products to more sophisticated equipment. There are assumptions also regarding the role of TNCs in participating in the model as suppliers of technology. In 1983, US$30m of imported semiconductors from OECD countries in Brazil reflect the extent of TNCs assembly activities in Brazil, and not of exporting Brazilian firms.

The PNI is also weak with respect to the support it gives to development of S&T in the country. The section below reviews the national S&T programmes over the last 15 to 20 years.

4.4 Science & Technology in Brazil

Chapters two and three showed that in addition to having explicit industrial policies to support national informatics industries, both AICs and NICs must have a parallel support to developing national S&T programmes. In the case of the AICs, the existence of a fully developed capital goods industry and a high level of science education have facilitated this objective (English & Watson Brown, 1985). All countries discussed in Chapter two have devoted large sums of money to support both basic and applied research.

While both first-tier Latin America and Asian NICs have developed national programmes to support S&T, the results are mixed. With respect to Brazil, a review of the available literature[1] and direct interviews carried out during field work in Brazil in 1988 with Brazilian professionals working in national S&T and R&D centres (CTI, NIT, NPCT, UFRJ, USP, UNICAMP), in the National Research Council (CNPq) and with the Ministry of Education (CAPES) show that S&T objectives have received inconsistent support from the government.

The first time the Brazilian government offered direct support to invest in a national technological capacity was in the 1960s through a BNDES funded S&T

[1] Klein & Delgado, 1988; Schwartzman, 1985, 1989; Schwartzman & Mora Castro, 1986.

programme. This plan involved at least three agencies who would coordinate national efforts in this area. These agencies included the National Fund for the Development of Science and Technology (FNDCT), the National Research Council (CNPq), and the Ministry of Education Centre's of Personnel Development (CAPES). This dissemination of resources between three agencies involved risk. On one hand if properly coordinated it could benefit different target groups managed by each institution. On the other, it could have a weaker role with the dispersal of limited S&T resources amongst too many players.

From 1970 to 1978, it was the turn of the FNDCT together with its executive secretariat (FINEP) to flourish as the key agency to coordinate S&T in Brazil. New post graduate programmes were created, old ones were reformed and expanded, the national research infrastructure was modernized.

The results of eight years of support were quite significant. Investments were made in numerous areas, including computer science and electronics. A 20,000 strong team of researchers directly and indirectly benefitted from that support, and one thousand graduate programmes in most fields of knowledge were created during that period. In 1985, Brazil was second only to India in the number of researchers and graduate programmes in the Third World (Schwartzman, 1985:6). Both the FNDCT and the executive secretariat FINEP enjoyed a privileged position within the restricted nucleus of policy making, while at the same time there were plenty of resources around and political power within the state to mobilize those resources (Klein & Delgado, 1988:28).

The situation changed after 1978. From that year to 1984 the FNDCT and FINEP experienced a marked political and institutional decline. Government funds for S&T were redistributed to other agencies including the National Research Council (CNPq) and the Ministry of Education (CAPES). During this period "support was provided to research groups deemed competent with a minimum of bureaucratic complications and by passing both the university administration and peer review procedures" (Schwartzman, 1985:6).

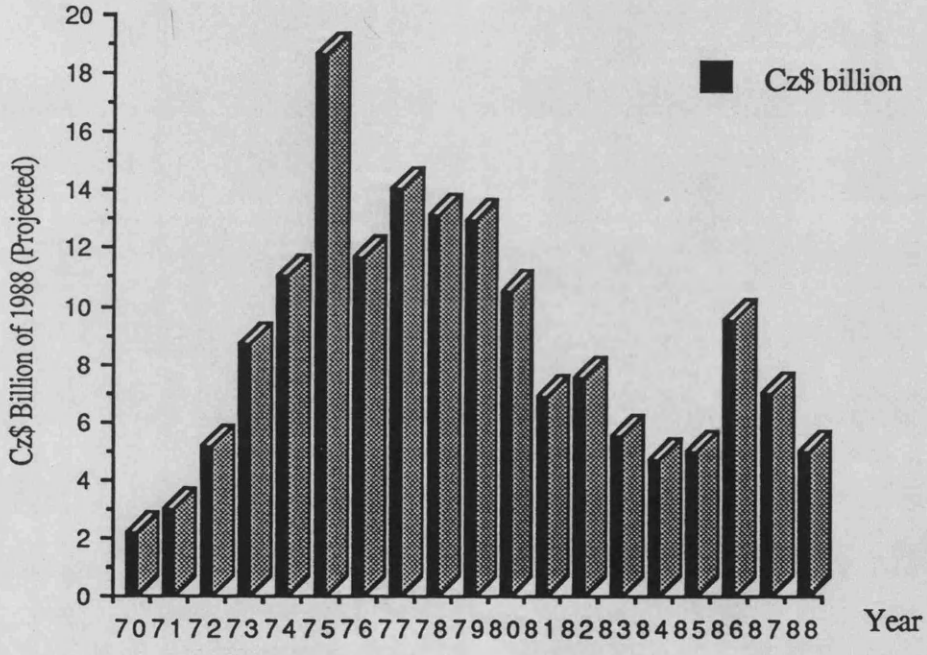
A few specific programmes received generous subsidies. In 1985, for example, the Coordination of Post Graduate Engineering (COPPE) received 29% of all FNDCT resources, In 1976, the Rio de Janeiro Catholic University (PUC-Rio) received 40% of the year's budget. In 1977 eleven institutions received 70% of the FNDCT funds (Klein

& Delgado, 1988:30).

The decline of FINEP and the rise of CNPq and CAPES represented both a transfer of financial resources from one group of agencies to another and a shift in political power from the Treasury (which oversaw the FNDCT) to the Secretariat of Planning (Klein & Delgado,1988:31). By 1983 CNPq had fought to become the national agency for S&T. Figure 4.4 indicates the fluctuation of resources made available to the FNDCT from 1970 to 1988. After 1980 the fund lost its political and economic power, which is has not recovered since.

Figure 4.4

National Fund for S&T - Resources Available 1970-1988



Source: FINEP (1987) in Klein & Delgado (1988:31)

Table 4.4 compares the distribution of resources between CNPq, CAPES and the FNDCT from 1980 to 1986. By 1985 the FNDCT received a limited 19% of the total S&T funds available while CNPq received 64% of them.

Table 4.4
Expenditure with S&T in CNPq, CAPES and FNDCT
1980-1986 (% values)

Agency/ Year	80	81	82	83	84	85	86
CNPq	41.9	53.4	52.2	60.3	60.8	64.0	48.8
CAPES	4.6	11.2	12.6	14.9	16.2	16.2	18.7
FNDCT	53.5	35.4	35.2	24.8	23.0	64.0	32.5

Source: Klein & Delgado (1988:32)

Government concern for S&T was institutionally quite specific. Under the newly formed New Republic in 1985 a Ministry of Science and Technology (MCT) was created. The Ministry's role was to concentrate otherwise dispersed efforts and to restructure the national S&T system. This aim, however, has never been achieved.

Other areas of the administration which had control over agencies involved in S&T reacted against the idea of concentrating all S&T under a new body. Interviews carried out in Brasilia in early 1988 with MINICOM's staff confirm this. The Ministry of Communications refused to renounce its control over telecommunications systems. The Ministry of Trade and Industry reacted to keep control over its Secretariat of Industrial Technology (STI). Both ministries argued that MCT would not have the necessary political and institutional connections with the end-users (the industries and consumers) of these new technologies.

MCT, as result, was given fewer centres to manage. SEI was moved from being under the auspices of the national security council as were the Council for Informatics (CONIN), the national laboratory (CTI), the export promotion zones (ZPEs) and the national research council (CNPq) (Folha de S. Paulo, 24/05/85).

S&T in the New Republic faced new problems, in addition to having a ministry with limited power to oversee and coordinate national programmes. According to Schwartzman from 1985 to 1988 the outlook for S&T in Brazil was negative. On a positive note, ideological discrimination and political restrictions imposed earlier on research were eliminated, cadres who had previously been nominated by politicians were now nominated by the scientific community, the mechanisms of selection, assessment and approval of research proposals and fellowships were made more transparent (Schwartzman, 1989:70).

Professionals working in the two largest grant giving/funding institutions in the country (CNPq and CAPES), concurred with these views during interviews carried out in 1988. It was acknowledged that both agencies had been able to enlarge their scholarship programmes[1], add new modalities of training (short and medium term training programmes), new areas of concentration (including all areas deemed to be in new technologies[2]), raise the levels of remuneration of researchers and university

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[1] CNPq was able to increase the total number of fellowships (in-country and abroad) from 12.921 in 1985 to 18.829 in 1987 (a 45% increase).

[2] These included: new materials, automation, informatics, biotechnology, telecommunications, software, and the social implications of technology.

professors and launch ambitious programmes of fellowships abroad.

The national budget for S&T during the New Republic, which theoretically was to increase, became totally unrealistic under the prevailing conditions of inflation and hyper-inflation of the national economy. In 1987 the total budget for S&T was Cz$17 billion representing 3.07% of the national budget. The breakdown of budget activities is described in table 4.5. In 1970 S&T received 0.84% of the national budget. In 1984 the figure increased to 3.2% and in 1986 it corresponded to 2.8% (Schwartzman, 1989:64).

Table 4.5
Breakdown of 1987 Budgeted Expenditures in S&T in Brazil
(Total budget Cz$17 billion)

Areas/Activities	%
Small stand alone projects & administrative function	40
20 large projects/activities @	60

@ Breakdown of expenditures in large projects	%
Military research purposes	36.6
Agriculture research	18.7
CNPq operations (including the FNDCT and all research institutes under CNPq)	28.4
Energy research	6.7
CAPES	5.8

Source: Schwartzman (1989:64)

This increase, however, has not been consistent. Both CAPES and CNPq have suffered from economic constraints faced by the country at large (inflation, lack of funds to invest, state bureaucracy), and have failed to develop comprehensive programmes to maximize the rates of return on new investments.

Events in CTI under SEI were no different in 1988. Set up in 1982 with an explicit mandate to promote the development of scientific and technological research in informatics[1], six years later, the Centre was facing financial difficulties, lacking basic

[1] CTI has four institutes. The first is responsible for R&D in the area of industrial automation (CAD,CAM, robotics); the second is responsible for R&D in digital instrumentation; the third in microelectronics (encapsulation, mounting and testing of ICs) and the last is responsible for R&D in

research funds to acquire new equipment deemed vital for research activities in the four areas of operation.

One area that has suffered is the human resource development programme *(Programa de Formacao de Recursos Humanos)*. This programme included training, institutional support to universities and research centres, development of effective monitoring and evaluation of training programmes and absorption of fellows who have completed their programmes in-country and abroad.

The quality and quantity of Brazilian scientific and technological capacity is therefore heterogeneous. While there is a large contingent of engineers and technicians in Brazil vis-a-vis other developing countries, both personnel and facilities are concentrated in the south east of the country. In 1985 the region accounted for 62% of all researchers, 65% of all research and teaching institutions, 66% of places in the universities, 74% of all masters programmes and 92% of all doctorate courses in the country (Schwartzman, 1989:65).

In addition to national programmes in support of S&T, individual states have devoted resources to research. The agencies with greater power and influence include the Foundation in Support of Research of the State of S. Paulo (FAPESP), a similar outfit for the State of Rio de Janeiro (FAPERJ), established in 1988, and one for Minas Geraes. The first obtains resources from state taxes, which in 1986 represented a meager 0.36% of the collection (Schwartzman, 1989:65). The former, has been forced out of business due to the lack of political support from state leaders.

In 1986 the World Bank initiated a programme in support of the development of science and technology in the country (PADCT). At the time of this research there was little information about the programme, which according to some was already facing problems with the payment of cost sharing contributions from the national government and with increasing external restrictions by foreign governments and manufacturers in the procurement of imported equipment and technology (one of the strong points of the original plan).

In 1988 the permanent scientific commission to the MCT, in a report presented at the 40th Annual Meeting of the Brazilian Society for the Development of Sciences (SBPC) affirmed:

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computer architecture and software.

> "By late 1988 the MCT was already debilitated, politically marginalized and susceptible to political party influences. The ministry was not always in tune with the interests of the Brazilian research community, and it was impotent to preserve and protect Brazilian research institutes and institutions from the impact of the national economic crisis." (Schwartzman, 1989:65).

In January 1989 the Ministry of Science and Technology was abolished by the Sarney Government. As one observer argued, the New Republic reduced and dispersed S&T resources amongst competing lobbying groups and political interests. The creation of a ministry was just not sufficient to give the sector the political weight it needed to continue supporting S&T in Brazil (Schwartzman, 1989:63).

To conclude, the fragility of the national system of S&T results from a fragmented and uneven support of S&T in the country. The absence of a more orchestrated programme covering S&T, human resource development, science education, R&D, interface industry/university has undermined and weakened the achievements made during periods of relative success of the national S&T policy. S&T also competed for limited resources with other major issues such as the national debt, urban crises, poverty and social pressures, labour strikes, indebted state enterprises, etc, and it has lost.

4.5 Summary & Conclusions

This chapter is the first of four to focus on the Brazilian informatics industry. The chapter examined primarily the National Informatics Policy (PNI), the context in which is has been formulated, the links (or absence of) with other sectors of the electronics complex, and the support for science and technology in the country.

The Brazilian experience, is however, hindered by obstacles created by the policy itself. Four areas of concern have been identified:

1) The high level of disarticulation of the national economy, industry and policy with the global context;

2) The closed circuit shape of the policy and its institutional rigidity represented by the law;

3) The disarticulation between informatics policies and other sectoral policies for the electronics complex;

4) Poor and inadequate support given to science & technology (S&T).

Firstly, the Brazilian experience with the development of informatics

over the last 25 years has gone through periods of economic growth and expansion (1970s) which naturally and positively influenced the events in the early years of the industry, and through periods of economic decline and extended crisis (the so called lost decade of 1980s). During these 25 years Brazil continued to rely primarily on import substitution strategies, to protect the national industry and markets from international control.

Import substitution did not favour the integration of national production systems with those in AICs and prevented national producers from becoming competitive abroad, and at the same time, it did not bring about the expected results (social and economic developments), which is visible in the 1990s.

Secondly, the focus for the policy. The main pillar of the PNI is the market protection of selected product/components markets which functions as a gauging mechanism to regulate technology transfer, to control the operations of foreign investors in Brazil, and to promote the development of indigenous technologies, firms, products and markets. In addition, the policy focused strictly on the production of hardware. SEI opted to consider software an immaterial technology, easily transportable, that could be copied onto disks or magnetic tapes and which was not to be protected by copyright laws (Piragibe, 1985:134). This position gave the green light to Brazilian producers to pirate all sorts of software and be protected by the absence of regulation. The decision also discouraged potential companies from seeing software development as a strategic and potentially profitable market.

Departing from a situation of disarticulation with the international logic, the experience of Brazil in bringing about a successful articulation of different industrial sectors (part of the electronics complex) and segments of society (government, universities, professional organizations), has been quite limited.

Digital technologies have brought together different industrial sectors into a single electronics complex (see in the Introduction). Leading TNCs have, in the course of their development, brought together these different sectors to gain further control of products and markets and to stay at the forefront of the technological race. In the review of AICs countries Chapter two indicated that Japan, France, and later the European Community, have constructed institutional mechanisms to facilitate this needed convergence of industrial sectors. In the United States the convergence has not been explicit from an institutional point of view, but has been organized around leading

American corporations. More recently, industrial collaboration and other forms of cooperation between companies, countries and regions have emerged offering new ways to facilitate the vital need for convergence of resources, expertise and capital.

The Brazilian experience has worked against convergence. It has been shown in this chapter that different policies were formulated for different sectors, the lack of a coordinating body to oversee the various policies contributed to that.

Lastly, the quality of support given to S&T in the country has had an impact on the sustainability of the policy and of the achievements made so far. Brazilian S&T has suffered from an uneven and fragmented institutional framework and inconsistent financial support. It has also faced the dilemmas of a country going through a long period of economic crisis and decline.

The next chapter focuses on the performance of selected sectors of the electronics complex. The chapter will provide further evidence about the Brazilian experience and substantiates the discussion on the interrelationships between the Brazilian and global industries.

CHAPTER V

V Structure & Performance of the Brazilian Informatics Industry

5.1 Introduction

Chapter four has focused on the political aspects of Brazil's informatics policy and industry, and on those of other countries (NICs and AICs). The purpose of this chapter is to examine the linkages between the Brazilian informatics industry and foreign ones looking at the level and competitiveness of the former. Three criteria of industrial performance are examined here: sales, employment and computer installations. Competitiveness is also measured by cost, quality and technological advancement of Brazilian-made products vis-a-vis international producers (external competitiveness).

In contrast with most product markets, performance in the electronic banking sector stands out. Using both primary and secondary sources of data, this sector is examined in this chapter for its unique and demand driven growth (section 5.2.4).

The data used in this chapter comes mainly from secondary sources in both government (SEI), industry associations (ABICOMP), business reviews (Gazeta Mercantil and Conjuntura Economica) and industry studies[1]. The type of data necessary to measure international competitiveness is export performance, but this is scanty. Since Brazilian producers have a limited export capacity and there is limited information on costs[2], this chapter also focuses on the internal competitiveness between Brazilian firms (including TNCs operating in the country), and at import flows (section 5.3). Another salient feature of the Brazilian industry is contraband and how it affects internal competitiveness. This issue is rarely addressed in the literature given its nature. Section 5.3.2.3 focuses on this theme. Finally, section 5.4 summarizes and concludes the chapter.

5.2 Structure and Performance of the Industry

This section examines sales, employment and computer installations.

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[1] Hewitt, 1988; Piragibe, 1985; Tigre, 1983, 1987.

[2] At the time of this research only two studies had been carried out looking at microcomputers (Tigre & Perine, 1984) and printers (Piragibe, 1984).

5.2.1 Sales

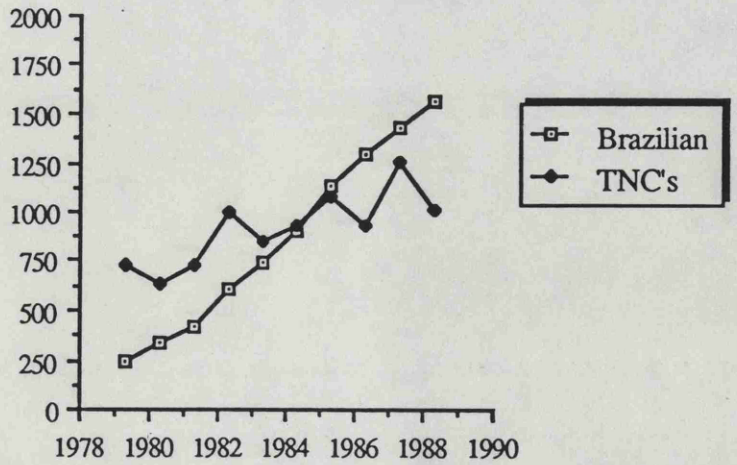
Over a period of ten years from 1979 to 1988 the national industry (including the activities of Brazilian based TNCs) rose to be among the top ten largest industrial sectors in the country. In 1988, the industry experienced a growth of 14.6% above the national average of 31 sectors of the economy (Tigre, 1988:6). At the same time profits of Brazilian owned firms have increased steadily from 1979 to the present. In 1987 profits exceeded those of Brazilian-based TNCs by US$ 444 million.[1]

Figure 5.1 shows the growth of total sales of Brazilian and TNCs in US$ million for the period indicated. Recapitulating from the previous chapter, the reasons behind this steady increase in sales lie behind the creation of a protected market in Brazil for the manufacture of small scale computers. The selection of the mini market as the starting point was a timely coincidence with technological developments occurring in computer architecture (reduction of machines and increase in processing capacity) (mid 1970s) and later on with the appearance of the microcomputer. Both developments opened new markets and found an untapped demand in Brazil.

TNCs operating in Brazil have experienced a more gradual increase in sales. TNCs operate in different product markets (mainframe and support systems) and have had their operations regulated by the market reserve policy.

Figure 5.1

Sales of Brazilian and Transnational Companies
US$ million



Source: SEI (1989:13)

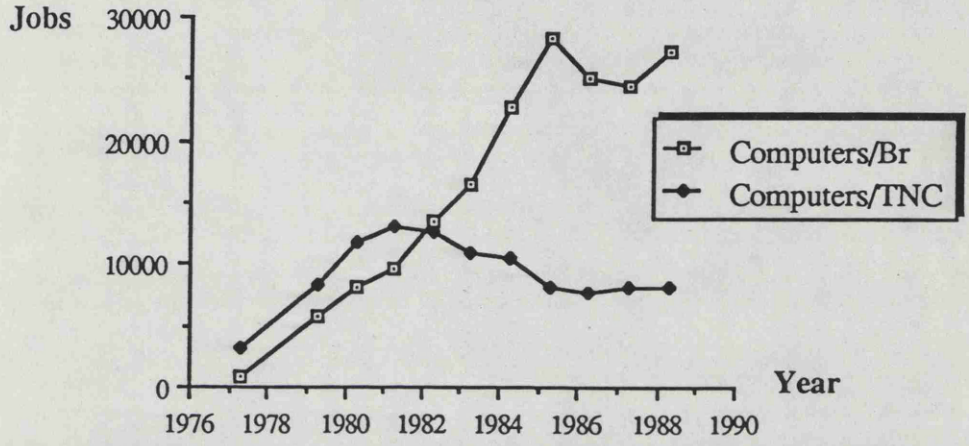
[1] *Informe Abicomp*, Encarte no. 18, no. 25/26 Aug 1988.

5.2.2 Employment

Brazilian firms have generated more jobs than their TNCs counterparts. Figure 5.2 demonstrates that employment in nationally-owned firms went from 50 in 1977 to 26,344 in 1988. Employment in the Brazilian based TNCs increased from 2,450 in 1977 to 7,383 in 1988 (SEI, 1989:34).

Figure 5.2

Employment Change in the Brazilian Informatics Industry



Source: SEI (1989:14)

Employment growth parallels company growth. In 1987 there were 300 domestic firms and 31 transnational corporations operating in the sector. Eight years earlier there were only 37 domestic and three TNCs operating in the sector. Most of those firms were created after 1976.

The position of informatics in the electronics complex in significant. In 1988 there were approximately 300,000 people working in the Brazilian electronics industry[1]. In 1988, informatics, telematics, industrial automation, digital instrumentation, and microelectronics sectors absorbed 68,264 employees, software and informatics services (e.g., maintenance, sales, software houses and training, consultancy) sectors accounted for 257,000 employees. From 1981 to 1986 employment grew by 330% in the domestic sector of the industry.[2]

Figure 5.3 shows this increase in five selected sectors, indicating the development of new sectors such as automation and instrumentation.

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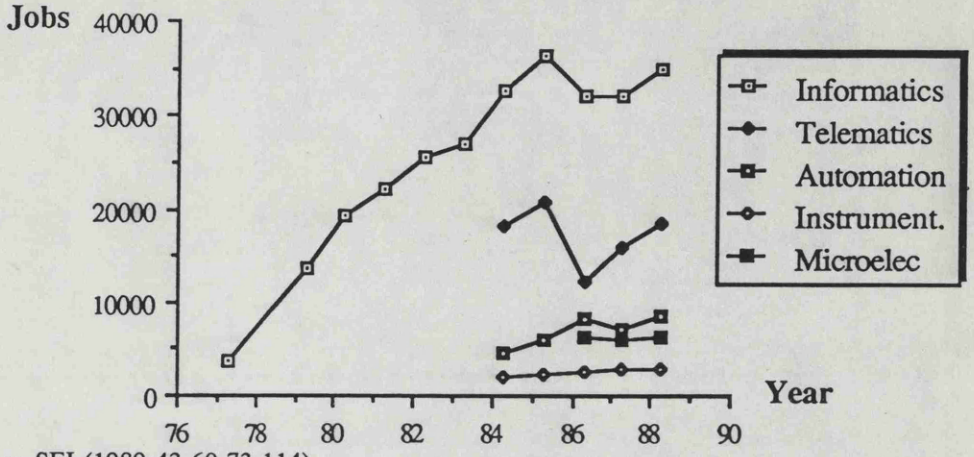
1 ***Informe Abicomp*** no.25/26 Aug 1988, and in "Recursos Humanos: o novo desafio a política de informática", ***Ciência Hoje***, vol.6 no.33, p.70-71.

2 ***Informe Abicomp*** no.25/26 Aug 1988, and in "Recursos Humanos: o novo desafio a política de informática", ***Ciência Hoje***, vol.6 no. 33, p.70-71.

Figure 5.3

Employment Change in the Brazilian Electronics Industry



Source: SEI (1989:43,60,73,114)

R&D jobs as a proportion of total employment is also an important criterion for measuring the quality of employment and nature of the productive activity within companies. SEI does not offer a definition of R&D in its industry survey. Tigre (1986), in turn, has classified R&D in terms of activities resulting in imitation, modification, design and innovation.

According to government sources, Brazilian-owned firms employ more R&D personnel than their TNCs counterparts (in 1988 16,184 and 5,300 respectively) (SEI, 1989:15). This not only has been confirmed by the survey but, echoed in interviews with managers of two of the largest TNCs in the country, who justified their limited focus on R&D as necessary to their corporate strategies (which are primarily concerned with marketing and effective customer support services). In 1983, TNCs employed 1,204 people in their marketing divisions, the equivalent to 42.8% of their university level employment. In 1987 there was a slight decrease to 36% of white collar jobs (SEI, 1989:25).

In the questionnaire I asked firms to list different sources of technology (direct import of parts, cloning, licencing, training) used in their operations, and different categories of R&D activities performed in their plants (as a production process, as a product, investments, market and managerial strategies). With respect to the first part of the question, most firms answered that they used direct import of parts and licensing as a way to gain access to imported technologies. Few firms admitted having heard/practiced cloning and other forms of industrial espionage and illicit practices to gain access to new technologies and/or to increase the value added of their products. R&D activities were difficult to measure given the different ways to classify R&D occupations. Responses given in interviews indicate that firms tended to group

employees who had technical and university education under R&D or product development categories. This was done to satisfy, in part, SEI's standard survey questionnaire. Firms admitted, however, that in practice workers might not be directly involved in any activity linked to R&D (e.g., product and process development, adaptation and testing). Many firms did not have a proper research and development division but carried R&D activities along with production. Only two companies stated that they had a separate R&D division.

Table 5.1 shows the proportion of higher education employment for Brazilian firms affiliated to Abicomp over three years. This table, however, clusters under the 'technicians' heading both those who might be involved in R&D (e.g., engineers working in process and product development) as well as tecnicos, or workers who have studied in technical vocational schools (e.g., electronics, electric engineering).

Table 5.1
Informatics Employees with Higher Degrees

year/category	*1986*	*1987*	*1988**
Technicians	6730	6489	6448
Sales Persons	3227	2592	2922
Administration	3815	2664	2591
Total	12772	11745	11961

* Figures for the first semester only
Source: Informe Abicomp, no.23 May 1988, no.28 Oct 1988

SEI monitors skilled employment by the quantity of university professionals employed and their activities according to five areas (production, marketing, product development, services, administration and human resources). According to this classification, in 1983 Brazilian firms employed 1,177 professionals in product development or 30.3% of the total number of university level employees. In 1987 they employed 1,818 or 25.2% (SEI, 1989:25).

TNCs in turn have fewer people engaged in R&D activities. In 1983 they employed 121 people in product development or 4.3% of their total white collar employment. By 1987, R&D employment totaled 213 jobs or 5.6% (SEI, 1989:25). Managers working in these firms confirmed that most of these posts were filled by engineers working on the adaptation of foreign made products and production processes to local conditions.

To conclude, Brazilian-owned firms have experienced a positive growth in sales and employment since the approval of the national informatics policy. In both criteria

they have had a better performance than their TNC counterparts.

This positive performance has to be seen in some perspective. Growth in sales by domestic firms have been possible by changes in computer technology and in market protection. While there has not been any significant change in the quality (value-added) of products sold by Brazilian owned firms, the types of products (product diversification) have increased.

Employment has grown in absolute terms in the Brazilian owned sector and it has stabilized in the TNCs. It has been shown that TNCs have maintained their focus on marketing and customer support services, which explains their limited number of R&D occupations. In the case of the Brazilian-owned sectors, employment has experienced a qualitative change with the upgrading of labour skills (Hewitt, 1988). The next criterion is computer installations.

5.2.3 Computer Installations

The first computers installed in Brazil were imported mainframe systems. In 1960, the first electronic computer was installed at the Catholic University of Rio de Janeiro. Following the inauguration of the PNI the first Brazilian built computer - the *Cobra* C530 came onto the market in 1979. Still, it was only after 1982, when nationally assembled micro computers hit the market, that the Brazilian owned industry began to grow.

Computer installations in Brazil are grouped, according to SEI's classification, into six different categories varying in size and power. Class 1 computers comprise the smallest machines produced in Brazil (8-bit), and Class 6 are mainframes. This classification has become obsolete as hardware technology has changed. SEI was aware of the problems with its data base but, at least during the time of the field work, it had not planned to reformulate its compilation system.

Table 5.2 indicates the increase in computer installations in Brazil from 1970 to 1987. Figures represent absolute numbers.

Table 5.2
Computer Installations in Brazil, 1970-1987

Class /yr	*70*	*73*	*75*	*77*	*79*	*81*	*83*	*85*	*86*	*87*
1	-	586	2143	3846	4791	8756	76289	352146	545285	707553
2	-	19	173	356	1015	2719	4133	5132	6772	8019
3	378	639	1057	1296	1494	1858	224	2710	3554	4585
4	122	250	327	353	377	408	430	660	717	827
5	2	45	82	122	226	374	711	866	1008	1147
6	4	33	61	87	97	134	232	198	299	453
Total	506	1572	3843	6060	8000	14249	80019	361736	557673	722649

Source: Informe Abicomp, Encarte 19, Sep 1988
SEI - Boletim Informativo, various issues

According to the table, the sharp rise in installations of computers in classes 1, 2 and 3 can be in part justified by the technological innovations in microelectronics which opened up new product and market frontiers. The first Brazilian produced micro computer came two years after their launch in the USA. National market protection led Brazilian firms to become focused and highly dependent on local sales. This national market, although large enough to accommodate a range of product lines, is still relatively limited in terms of scale. There are also far too many manufacturers, especially of micro computers (37 in 1985 and 25 in 1988) whose licence to produce has been given by SEI. Consequently, most of the products are produced on a batch process and with low levels of automation.[1] That, coupled with a rather inefficient and poorly structured final producer-supplier relationship; the absence of a well developed nationally-owned electronic supply industry (the consumer electronics sector is dominated by Brazilian based TNCs); the dependency on crucial imported components; and unfavorable exchange rates make even batch production a rather irregular activity.

The table of computer installations has to be looked at selectively. The number of installations increased from 506 in 1970 to 722,649 in 1987, as has the value of the existing installed capacity. The Brazilian owned sector is also increasing its share of the total value of installed capacity. However, Brazilian participation is based on the commercialization of standard low-technology systems (16 bit micros, serial printer and 5.1/4 drives). Top selling products in 1987 were printers (92,796 units), drivers

[1] in Personal interviews, company questionnaires. See also Frischtak, 1986:1.

(61,637 u), 16 bit micros (59,239 u), 20MB hard disks (32,222) and modems (30,532).[1]

It is difficult to determine the type of application given to these systems. Financial sectors and industry lead in the number of installed systems, followed by commerce, government and the services industries. Table 5.3 shows the distribution of demand among sectors of the economy. This point will be further discussed in Chapter six.

Table 5.3
Demand for Informatics Goods by the Different Sectors of the Economy
1980 to 1987 (%)

Economic Activity	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*
Government	17.7	15.9	11.9	9.0	13.2	12.5	16.24	15.87
Commerce	34.5*	37.9*	19.6	16.8	19.4	18.3	21.47	19.2
Industry	26.2	25.6	29.1	28.2	27.7	32.5	31.79	33.03
Financial Sector"	20.7	19.4	29.6	30.4	29.5	28.0	21.61	21.07
Services	-	-	9.8	15.6	10.3	8.7	9.89	10.83

* Includes services
" Includes both public and private financial sectors
Source: SEI (1989:23)

Many different sectors of the economy now use computers in Brazil. In most cases these systems comprise large mainframe systems to perform large scale computations.[2]

During visits to offices and plants, I was able to observe that the introduction of Brazilian built informatics systems was, to some extent, replacing manual tasks by automated or partially-automated ones. These included a range of office work, inventory control, equipment testing. This was also quite evident in the banking and commercial sectors. The existing product/application structures were, however, far from allowing users to utilize informatics systems as tools for knowledge production. The simplicity of nationally-built systems, the strict regulations on imports of the most sophisticated equipment, and limited resources for R&D, hampered the process of modernization of user sectors both in terms of their access to state-of-the-art technologies (from abroad), the low quality/performance ratio of Brazilian-made

[1] ***Informe Abicomp***, no.23, May 1988:3 "Produtos comercializados pela indústria nacional".

[2] ***Dados e Ideias***, no.126, 1988 "As 500 Maiores Empresas Usuarias de Informatica".

products, and the manufacturers' poor customer support and maintenance infrastructure. Furthermore computer installed capacity should not necessarily be related to economic growth. In 1988 the number of Brazilian large computers installed (9203 units) was five and a half times larger that of Korea (1646 units) and the latter enjoyed a more stable and promising economic life than Brazil (Tigre, 1988:3).

To conclude, these criteria (sales, employment and installed capacity) are useful in measuring industrial performance as the figures unquestionably confirm the merit of the PNI in creating a sector that did not exist and making it into what it is today. One must, however, be cautious when looking at the aggregate data available on industrial performance in terms of its credibility and representation and in what it conceals about the present industry structure. The efforts to desegregate the indicators chosen - sales, employment and machine installations - run into issues of confidentiality and firms' secretiveness about revealing information or disclosing corporate strategies that conflict with policy principles. An area often referred to during interviews was the growing volume of illicit importation of parts and components as a way to bypass import barriers and to reduce costs. Chapter seven returns to this point looking at spatial concentration and dispersal of firms, users and sales in different parts of the country.

One subsector of the national informatics industry that has performed well is electronic banking. This success has not been analyzed by the literature, which, as mentioned in the Introduction, has focused on aggregate performance in the sector as a whole. Successes in electronic banking bring together many elements of the development of the industry and these are discussed below.

5.2.4 Breaking Technological Barriers: Electronic Banking

The purpose of this section is to examine one sub-sector of the informatics industry which has performed significantly well, driven by growing demands from users, in this case the banks. Many banks, in turn, own or have large stakes in some of Brazil's largest informatics companies. What is particularly interesting about this sub-sector is the successful match of bank's informatization needs with the level of technological capability of national firms.

Brazilian banks have used new information technologies to assist them in restructuring their internal financial operations to keep up with volatile changes in the Brazilian economy. Rising inflation and indexation of the economy forced banks to seek new more effective data management mechanisms, and to develop new customer-user interface to give clients access to vital information.

The information used in this section was collected during field work in 1987 and 1988 from primary sources (interviews with managers of 3 banks - Itau, Bradesco and BNDES, and with companies owned by these banks) and secondary sources (articles in the press and government data).

In the early 1970s banking automation was unknown in Brazil. Industrial activity in this sub-sector was insignificant and a potential market was yet to be developed. Table 5.3 above demonstrates the increasing demand from the financial sector for informatics goods. Between 1980 and 1984, when sales of equipment peaked, the sector increased its participation by 9.5% points. This demand, coupled with a strong campaign to promote a national informatics industry, attracted financial and other capitals to enter the sector. The market protection artificially lowered entry barriers and gave nationally-owned companies a guarantee of return on their investment.

According to managers in three of the largest banks in the country, banks found in the government offer an opportunity to diversify their investments into areas outside its financial sector, while at the same time enabling them to introduce informatics into the banking system.

Research shows that banks entered into partnerships or became sole investors, in many national companies. Some of these banks have a long tradition in industry. Group Itau SA, a conglomerate with stakes in the financial sector (Itau Bank), the industrial sector, the informatics sector (Itautec), and microelectronics (Itaucom, and later Itaucam). Others, like the Bradesco Bank, started solely as a financial and insurance company with no experience in industry. Bradesco began the introduction of on-line access to its network by purchasing custom-made equipment from Sid Informática and Digilab. In 1983, it increased its control over the latter. Ownership of Digilab gives the bank direct access to activities in the electronics sector (Veja 5/05/89:99). Elebra Eletronica, another giant, has subdivisions in all sub sectors except consumer electronics and is partially owned by the national development bank, BNDESPar (29.53%) and City Bank (22.96%). Cobra Computadores is owned by three banks: Banco do Brasil (31.1%), BNDES (31.5%) and Caixa Economica Federal (31.4%).[1]

Once the first banks began to automate part of their activities other financial institutions felt the need to modify their conventional systems to keep up with the

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[1]The remaining 1.4% belongs to Digilab, which in turn is controlled by Bradesco.

competition. Today the three national banks (*Banco Central, Banco do Brasil* and *Caixa Economica Federal*), ten state banks (or 41% of the private commercial state banks in the country), 25 private commercial banks and 6 development banks (including the BNDES) are extensively equipped with electronic facilities. Informatization levels vary from case to case.

Banks' investments in electronics have concentrated in two areas, the development of customer support services and back office automation. With respect to the first area, these services include various levels of branch automation, on-line processing of current/deposit accounts, automated teller machines, on-line account information, etc. Banks are also investing in data communication via satellite and on-line connection of the banks net-works. In 1989 the State Bank of Pernambuco invested US$ 2 million to link its 142 branches and to triple its processing capacity. Itau and Bradesco use communication via satellite to monitor their national networks. Bradesco has the largest installed computer capacity in the country with 29 mainframes and superminis connected into a network of 41,000 terminals and some 2,000 micro computers. According to the Bank, by the end of 1988, 77% of its 1,692 branches were connected on-line.

After 1986, banks began to diversify the informatization of their back-office operations to improve efficiency. Machines are now also being used for pay roll, branch inventory and other administrative tasks.

The demand for digital equipment by banks and other financial institutions is on the increase. In 1986, 11,586 pieces of equipment were sold. These included teller machines, cpu/concentrators and banking terminals. In 1987, total sales decreased to 10,228 units, only to double in 1988 (24,477 units sold) (SEI, 1989:33). Major producers are companies owned by the banks. SID and Itautec are the largest producers of ATM's (automated teller machines) and banking terminals (9000 units sold in 1988). They also produce central processing units (CPU's) and automated deposit teller terminals.

Producers of electronic banking equipment have been plagued by the economic problems affecting the country at large. These include poor sourcing, unfair competition practices, economic instability and lack of qualified labour (SEI, 1989:37). On the other hand, banks have been sheltered by their financially strong holdings and, as a result, have additional mechanisms to cope with some of these difficulties. Itautec, for example, invests in job training schemes which include specialization courses in and outside Brazil. The company invests in R&D to cope with the bank's increasing demand

for complex and sophisticated equipment and software. At the Itau Research Centre, computing personnel are currently working on specialist systems such as SEIS (System Installations Support) and on the development of management specialist systems to perform risk analysis. Banks are also working on applications to cope with and respond to a continuous change in economic indexation including inflation.

On the whole, banks have done quite well both as industrial actors and as consumers of digital equipment. Electronic banking in Brazil began at the customer level, firstly restricted to those who had access to bank services and accounts; secondly to make customer use of selected services easier with fast and efficient access to information and transactions. The banks managed to become almost the centre of the country's economic life in periods of high inflation, and to be reservoirs of financial investment and transaction for a sizeable portion of the national population. Informatization allowed some of the national commercial banks to compete more efficiently at the level of customer services and data processing of their transactions, increasing an already concentrated national banking structure.

With the rapid changes in the country's economy from the early 1980s onward, electronic banking technology has become a strategic tool to cope with complex indexation systems and a volatile financial market. Financial investments become one of the most attractive areas for operation under Brazil's high inflation system. In 1988, two of Brazil's largest banks, Itau and Bradesco, achieved profits of 54% and 75% over 1987. Again, the success in this particular niche should indicate that they were more a result of banks' capital liquidity aided by a protective policy, rather than a result of the policy itself.

5.2.5 Summary and Conclusions

According to the above criteria the Brazilian informatics industry has performed well during the first six years of the policy. Both the number of firms and the levels and quality of employment have increased. Sales by national companies have surpassed those by TNCs. National capitalists control 61% of the domestic market (or US$ 1505 million in 1988), and Brazilian-made equipment forms the bulk of the country's installed capacity.

The apparent dynamism of the national industry described by the government and other industrial analysts does not make clear the position of Brazil's domestic industry vis-a-vis the international one.

5.3 Brazilian Informatics and the International Division of Labour

5.3.1 National Versus International Capital

This section examines the position of Brazilian firms vis-a-vis TNCs operating in Brazil, and identifies the role of national companies in the international division of labour. This is done by examining trade patterns.

The logic pursued and defended by the world's industry leaders percolates through the Brazilian case via the activities of Brazilian-based TNCs. In spite of the market reserve instrument, TNCs have managed to maintain a foothold in most of the Brazilian electronic sectors. TNCs control the majority of business in consumer electronics, telecommunications and microelectronics. They are key providers of technologies to Brazilian companies: their product, design and basic technologies are cloned by local hardware producers, and they retain 40% of the total national market. The mainframe market reproduces the oligopolistic and concentrated structure of the world industry. IBM controls 60% of this market alone, as shown in Table 5.4

Table 5.4
Mainframe Market Shares of Brazilian Based TNCs 1976-1982

Firms (%)	*1976*	*1978*	*1980*	*1982*
IBM	64.9	65.6	63.2	61.8
Burroughs	17.1	16.6	14.5	14.3
CII-Honeywell Bull	6.4	5.8	6.8	6.9
DEC	3.0	3.2	3.7	3.8
Univac	2.3	3.5	3.9	2.9
H. Packard	3.1	1.7	4.2	2.8
Fujitsu	0.8	1.5	1.9	2.6
Other US firms (1)	1.6	1.5	0.2	2.4
Other European firms (2)	0.8	0.8	0.2	0.1
Brazilian firms (3)	-	-	-	2.3

(1) Control Data, NCR, Data General, Datapoint
(2) ICL, Thompson
(3) Sisco, Cobra, Labo, Medidata
Source: SEI reproduced in Piragibe (1985:61)

Foreign direct investment by TNCs operating in the informatics sector is not new in Brazil. IBM started production operations in the country in 1939, Burroughs in 1953, and up to 1981, other TNCs continued to choose Brazil as a site for their activities (See Table 5.5) (Piragibe, 1985:111). As there was no domestic production

of informatics equipment in the country, Brazilian based TNC subsidiaries dominated the national market for those goods, maintaining the oligopolistic structure characteristic of the world industry. Thus, rather than argue that "the national industry was born internationalized" (Piragibe, 1985), I suggest that as early as the 1960s Brazil was already part of the international division of labour for informatics. After 1979, however, when *Cobra* launched its first Brazilian made computer and state intervention was already consolidated, the structure and performance of the sector began to change.

Table 5.5
Subsidiaries of TNCs based in Brazil
First Year of Activities and Origin

Company	*Year*	*Country*
IBM	1924	USA
Burroughs	1924	USA
Sperry	1950	USA
Olivetti	1952	Italy
NCR	1957	USA
Honeywell	1960	USA
Hewlett-Packard	1967	USA
Fujitsu	1972	Japan
Control Data	1974	USA
Digital	1974	USA
Data General	1975	USA
Datapoint	1981	USA

Source: Piragibe (1985:11)

TNCs interviewed during the field work and asked to comment on the impact of the policy on their operations confirmed their opposition to the changes brought by the national policy, and they have decreased their presence in the last fifteen years on many fronts. One example is Olivetti, which restricted its activities to non-digital office equipment after long battles with SEI to obtain a licence to produce digital equipment locally. IBM and Unisys, in turn, opted to adjust their products and market strategies to fit into the narrow but profitable medium and large frame market sectors. They also produced parts and components for the domestic and, most importantly, export markets.

TNCs were also uneasy about the future of their operations in Brazil prior to approval of the law. However, once the period of turbulence passed, TNCs gained through the political campaign to approve the law and educate groups of society of the

importance of informatics.

According to interviewees, the national campaign to promote the new policy helped to develop an informatics image and the implications it had on people's lives and work patterns. In the absence of a nationally-made computer, Brazilian firms involved in production opted to develop clones of IBM's and make national machines compatible with the IBM system. IBM clones and the reproduction of the company's brand by Brazilian firms helped IBM's corporate image, quality and reputation. IBM compatible machines also use a range of existing software produced for the original machine.

Another area in which TNCs benefitted from the policy was in the sole control of the mainframe market. These systems require for their functioning an infrastructure of peripherals provided by local producers. Thus, TNCs concentrate their resources on the provision of high quality product and services and leave to the national sector the difficult task of developing a local market, of educating potential consumers to use computers, and of interacting directly with users of their equipment.

The lack of experience of Brazilian firms in providing extensive and efficient customer/machine support services has forced local producers to endure the difficulties of learning-by-doing as they are confronted with crucial aspects of systems analysis and design, customer support and machine maintenance. TNCs, on the other hand, focus on marketing products with which they are fully familiar.

In short, the Brazilian strategy has not threatened the positions of the TNCs already established in Brazil. The challenge to alter the existing international division of labour in the informatics industry is enhanced by the diverging trajectories of Brazilian-owned companies and Brazilian-based TNCs. While the former are surrounded by protective mechanisms, the latter have not only found a place in the national markets, but have benefitted from the existing policy to reproduce the current international division of labour domestically. In many ways the TNCs have a market reserve controlling the mainframe markets and technological tendencies in the country. IBM defines business in Brazil as "an opportunity for further growth where profits in data processing equipment are only 1% of the gross domestic product, and where the current economic volatility and crisis is managed with short term business plans and with a 25% growth in 1988" (Dados e Ideias, Aug 1989:30). One of the few firms able to think of strategic planning (IBM) has been behind the national subsidiary corporate support to back an investment of US$ 100 million in 1988 (Dados e Ideas, Aug 1989).

5.3.2 Trade Patterns

Trade patterns in this industry show the nature of internal and external competitiveness, the divisions of labour between Brazilian-based overseas subsidiaries, Brazilian-owned firms and the latter's relationship with the international informatics industrial complex.

Brazilian-based TNCs have chosen Brazil as a location for their activities as part of their worldwide market expansion strategy. Domestic firms, on the other hand, are heavily dependent on the internal market to sell their products and on the external markets to obtain key components not yet produced domestically. Small scales of production, feeble product quality and prices above most other international competitors make their export activity virtually nil.

5.3.2.1 Imports

Aggregate import figures show that imports of informatics goods have suffered an overall decrease since the appearance of Brazilian owned companies in the local informatics industry. Prior to 1979 the country was a net importer of informatics goods, with both domestic firms and TNCs subsidiaries accounting for this demand.

While total imports of informatics decreased from US$ 600m to US$ 300m, the imports from Brazilian based companies have gradually risen. Between 1981 and 1987 Brazilian firms brought in over US$ 600 million of imports, discounting the large smuggling trade that goes on un-declared. The presence of Brazilian firms in production contributed to a decrease in imports of computer systems while the demand for components, both from informatics and other sectors continued to rise. A study done by ABICOMP in 1988 demonstrated that national firms' greatest demand was for electronics components, corresponding to 67% of total imports in 1985/86.[1]

Brazilian-based TNCs were more secretive about their transactions in responding to questionnaires and interviews. Over 50% of imports of Brazilian-based overseas firms consisted of parts and components for electronic machinery, devices (e.g., for printers, disk drives, etc), since the quality and standard of Brazilian made mechanical devices were below international levels.[2]

From the user's point of view the public sector continues to be the biggest consumer of informatics goods. During the 1985/86, the government authorized US$482

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[1] ***Informe Abicomp,*** no. 21 Encarte 14, Feb 1988 "Importações: Nacionais e Multinacionais."

[2] ***Informe Abicomp,*** no. 21 Encarte 14, Feb 1988 "Importações: Nacionais e Multinacionais."

million in imports. The trade and services sector accounted for 31%, followed by data processing services of 30%, the banking sector of 16%, and 23% divided between agriculture, education, and social programmes. Industrial demand was highest in the mechanics sector, 31%, followed by telecommunications 29%, energy 9%, and steel 7%. Table 5.6 gives government figures on authorized imports between 1982 and 1988.

Table 5.6
Authorized Imports of Informatics Goods, 1982-1988
US$ million

Year	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*
Br. Firms	50	49	90	96	93	106	110
TNCs	208	179	187	174	187	216	268
Total	258	228	277	270	280	322	378

Source: SEI (1989:34)

5.3.2.2 Exports

Export activities measure external competitiveness, that is the ability of firms to operate in international markets and to succeed. There is a clear distinction between export activities of Brazilian based TNCs and Brazilian owned firms. Up to 1989 the export activity in informatics was almost entirely restricted to the activities of Brazilian based overseas firms. Domestic firms, on the other hand, have shown a mediocre performance in export markets. Those firms that have exported admitted having done so to try their luck in foreign markets.

Table 5.7 compares export performance of Brazilian firms and Brazilian based TNCs over three years. The table shows IBM's overwhelming dominance of the international markets, followed by TNCs and national firms.

Table 5.7
Exports of Informatics Equipment, 1986-1988
US$ million

Year	*1986*	*1987*	*1988*
Brazilian Firms	1	2	5
TNCs	204	161	226
IBM	175.1	135.6	183.0
Total	205.0	163.0	231.0

Source: SEI (1989:35)

IBM first started to export in 1955, selling its electronic classifiers IBM-082 to

eleven Central and South American countries.[1] In 1967, 50 years after the company set up in Brazil, 94% of its total output, worth over US$ 9 million, was exported.[2] The approval of the policy has forced IBM to alter its outward-looking profit repatriation strategy to focus on Brazil. By 1982 IBM enlarged its share of the domestic market, keeping one third of its production in the country and exporting the rest to its many worldwide subsidiaries. There has been little change since then. In 1987 the company exported US$ 135.6 million, reflecting a sizable decline from 1986 (US$ 175,1 million). In addition, the company created IPO (in 1985) an International Procurement Office to buy-in local components, parts and sub-systems to supply IBM's international demands.

The experience of Brazilian firms in international markets has been limited. *Elebra Informática* for example, opted to do subcontracting work for American-based TNCs who provided them with the necessary technology. In 1984 Brazilian firms exported US$ 4.1 million worth of magnetic disk circuit boards to Control Data (Tigre, 1987:76), but this represented only a small percentage of the company's business. According to interviewees' responses, these subcontracting arrangements were not, however, a guaranteed source of revenue. Alternatively, firms have tried to penetrate regional markets of South America hoping to benefit from the geographical proximity. *Microdigital*, a micro computer producer, between 1984 and 1987 sold US$ 3.5 million worth of its TK product line to various LA countries. *Digitel*, on the other hand, was not so successful exporting peripherals to the United States. Its modems and other communication equipment were often returned with faults and the packaging was not adequate for the American transport systems. The company preferred to concentrate on the domestic market rather than risk their survival in the highly demanding and selective American environment.[3] Even producers of banking automation systems have tried to test their products abroad. *Digirede* sold systems to Interbanco in Paraguay, *Itautec* to the *Banco Português do Atlântico*, Portugal and *Sid* to the *Banco del Sud* in Argentina. Some application software is now being sold to North and South American markets.

The reasons behind this weak performance of Brazilian-owned firms go back to the industrialization period. The import substitution model used to promote Brazilian

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[1] IBM Brasil, "70 Anos" Brochure produced by IBM do Brasil in celebration of its 70 years of activities in the country.

[2] IBM Brasil, "70 Anos"

[3] *Dados e Idéias*, Sep 1987:55 "Por Mares Nunca Dantes Navegados."

industrialization curtailed most efforts to develop an export capacity in the country. Under this scheme, the domestic market has been sheltered from foreign competitors while it favours local capital. Companies wishing to produce for external markets have had to bear the burden of domestic production costs and yet offer a product at a competitive international price. There has been an emphasis on subsidizing production for domestic rather than external markets. This was true in Brazil until the late-1960s when government officials realized the importance of export markets as an additional source of revenue. In spite of the emphasis put on the export sector during the 'miracle' years, it has not been sufficient to strengthen the country's fragile export base. This has affected the Brazilian informatics sector, and the other sectors of the electronics complex.

On a more recent note, the decline in the industry's average profit rate from 28.10% in 1985 to 8.19% in 1987, and the uncertainties of the Brazilian economy, have led industrialists and government officials alike to turn towards external markets.[1] On the macro scale, the government began a mini-currency devaluation programme to make Brazilian products cheaper abroad.[2] On the micro-scale, based on previous export experiences, industrialists felt the need to invest in original products and niche markets in order to survive the toughness of foreign markets. As already discussed above, the banking sector was a good example of niche strategy that worked.

It is not only historical reasons connected to the import substitution models which make exporting difficult. The lack of significant industrial activity in the informatics sector throughout Latin America has led to a widespread market dominance by leading TNCs. As a result, Brazilian products often have to compete against better quality and lower priced brand-named products. In the countries where there is some export activity, its situation is further aggravated by the presence of high import tax restrictions. Brazil and Colombia have the highest tariff on informatics imports (45%), while the rest of Latin America average a 20% tariff (Correa, 1988:40).

Brazilian owned companies, as has already been demonstrated, depend on their international suppliers for the provision of those components they cannot produce locally or for which local production is not feasible (small markets, limited technological capacity, etc.).

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[1] ***Informe Abicomp***, no.31, May/Jul 1989 "Faturamento da Indústria Nacional de Computadores."

[2] ***Dados e Idéias***, Sep 1987:54-56 "Por mares nunca dantes navegados."

Export activity, on the other hand, offers an alternative to declining domestic rates of return and to the saturation of national markets for specific products. That in itself can be a driving mechanism to force Brazilian firms into the exports market as an alternative to the domestic ones, specially during periods of recession. Responses at interviews with companies that have exported confirmed this point. The possibility of profit squeezes was the main motivation for Brazilian firms to test their performance on foreign markets. In addition to discouraging export activity amongst Brazilian firms, the market reserve and the conditions it imposed on firms affiliated with SEI, created the conditions for 'back door' activities such as traffic in contraband and the development of unfair industrial practices in the industry. These two processes jeopardize the national commitment to develop a national indigenous technological capacity. They are reviewed below.

5.3.2.3 Contraband and Other Forms of Unfair Competition

It has already been pointed out that the Brazilian informatics policy offers protection and incentives to local informatics firms. In return for these benefits it demands a degree of commitment from industry to abide and conform to tough restrictions put on their business activity. Import restrictions, high costs (and risks) of R&D, lack of skilled labour and the country's overall economic uncertainty can damage companies' economic health and alter the otherwise positive corporate business attitude towards the national targets. Smuggling and unfair competition offer ways around some of the difficulties imposed by the policy.

The purpose of this section is to look at the these activities and try to determine to what extent and how they have affected production and marketing activities in Brazil. The primary data used in this section was collected during field work in Brazil in 1987-1988 in interviews with manufacturers, consumers, computer repair shops in S. Paulo, SEI staff and staff at the Federal Police. Secondary sources used include articles from the press and data from the Federal Police.

By and large, Brazilian firms have used contraband as a solution to import restrictions. Measuring the volume and impact of contraband on the local industry is very difficult given the nature of the activity. However, estimates for 1987 value smuggled merchandise at between US$ 50m and US$ 300m or anywhere from 15% to 100% of the industry's authorized imports for the same year (US$ 320 million).[1]

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[1] ***Informatica Hoje***, Set. 1985; ***Jornal do Brazil,*** 21/04/87, and ***Exame***, 08/07/87.

According to field research carried out in 1988, the simplest way of purchasing illegally imported equipment in Brazil was by responding to advertisements or by direct telephone orders. Local newspapers advertised state-of-the-art personal computers and peripherals for prices given in US dollars or in Cruzados reflecting a price anywhere from 25 to 100% above those quoted in the American market. Alternatively, those demands could be made directly to well-established smugglers. Their prices also included sums to cover special service and enhancements added to the product or other services including home or office delivery. Products available through smugglers were not solely limited to micros. These organized smugglers could supply CAD/CAM equipment, components, laser printers and even mainframes. Goods came primarily from Korea and Thailand, who supply primarily cheaper and higher quality peripherals and components; and from state-of-the-art manufactured equipment in Japan and the United States.[1] Whatever variety of contraband and its origin, in 1987 there were 14,000 Apple Macintosh machines installed in the country. This installed base represented over half of the total sales of CCE, a Brazilian Apple clone producer up to 1986 (25000 units sold).

The ways to monitor and punish those who break the law were multiple. SEI had made available to the Federal Police its detailed records on how many, by whom, when and where every computer system, components and peripherals were legally imported into Brazil. The Customs Division of the Police referred to these whenever it held one of its "Contraband prevention and suppression raids". In 1987, during one of these operations, Cz$ 48.8m worth of equipment was apprehended in 213 firms out of a total of 2141 firms visited. Integrated circuit boards were the most abundant smuggled product found, followed by memory chips and printers. Although the name of the firms were kept secret the operation included equipment inspections in large banks, TNCs offices and others (see table 5.8).[2]

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[1] Information provided by the *Secretaria da Receita Federal* - Federal Police, interview.

[2] ***Jornal do Brasil***, 24/04/87 "Receita reprime contrabando de equipamento de informatica."

Table 5.8
Smuggled Products Seized by the Federal Police
Selected List - March 1987

Product	*Quantity*	*Product*	*Quantity*
Hard disks	48	Video terminal	65
Key board	126	Microcomputers	181
Printers	216	Disk drives	223
1/4 Diskettes	1938	Memory chips	1269
ICs	11922	-	-

Source: Secretaria da Receita Federal

According to the Federal Police, contraband tended to increase when producers were faced with profit squeezes and reduced returns. It was a strategy of technological appropriation that gave smugglers a leading edge over competitors without the risk, and above all the cost, of initial investments on R&D. The government was obviously disturbed by these practices and took initiatives to curtail them. From the firms' point of view smuggling was a way to evade import taxes even if it interfered with national objectives to induce local companies to develop their own product technologies.

From the industry's point of view contraband was a double edged knife. 'Loyal' producers found themselves sharing their markets with smuggled products which performed the same functions but cost less. At the same time substituting national for foreign technology secured them a stable market and cut corners and investments in home made technological development. Users had yet another view on the matter. Smuggled goods satisfied most users' demands and spared the user from struggling with Brazilian producers and Brazilian products.

The usually advantageous price/quality ratio of foreign goods stood behind the rationale of smuggling. Even with the 20-30% profit added to the product's price tag, smuggled goods were often cheaper than Brazilian manufactured ones. A local producer admitted having lost a sale option because its product was more expensive and had a 90 to 120 day longer delivery wait than a smuggled one.[1] While no other firm was able to provide concrete information on this subject, interviewees did not discard the possibility that this could occur vis-a-vis their competitors. Table 5.9 compares the market price of smuggled and nationally made goods.

[1] Information obtained through interviews

Table 5.9
The "Best-sellers" of the Parallel Market, March 1987

Products	*Average Price in Br. Cruzados*	
	Cost of national product	*Cost of smuggled product*
Hard disk 20MB	125,000	28,000
Microcomputer 16b (+2 drives, no monitor)	70,000-150,000	60,000 - 250,000
Memory chips	120 - 500	50 - 60
Printers	70,000	40,000

Source: "A porta aberta do Contrabando" *Exame*, 08/07/87:62

Another informant argued that his firm had smuggled goods into the country as a way of avoiding the intricate bureaucracy to obtain import permissions, of bypassing high costs and time investment to train workers and of the lack of capital to develop new products and markets. This was the case of hard disks. These products were first produced in Brazil in 1989. The demand for them, however, was already high, given the size of an already solidly established base of installed microcomputers. As local demand exceeded production, and production rigidities made flexible production impossible, the industry was prepared to accept smuggling to make up the gaps.

Brand names and companies' credit-worthiness also work in favour of contraband. Owners of Brazilian-made equipment often had to put up with precarious and inefficient customer support services as Brazilian producers have not yet developed a sound distribution and marketing strategy. Still, smuggled foreign goods are preferred, despite the greater risks involved in the purchase of more technologically sophisticated equipment where little or no technical assistance is available. A local computer technical assistance shop in S. Paulo declared that, out of the 1000 machines examined each month 100 to 200 were foreign made. If the product could not be repaired owners were usually prepared to send for additional parts or even ship the machine itself to be mended in the United States.[1]

To conclude, contraband jeopardized companies that opt to follow the guidelines of the national policy as they became subject to the predatory competitiveness of firms that didn't. During field work in 1989 ABICOMP, the producers' association, was to launch an 'Ethical Code of Practice' to alert consumers to the problem. The hope was that informed consumers would deter themselves from buying products from companies

[1] *Exame*, 08/07/87:64 "A porta aberta do contrabando".

who failed to follow the code.

On the whole, trade patterns discussed here reveal the inability of the national informatics policy and of the industry itself to alter the existing international division of labour between companies and countries producing new ideas and concepts, and the countries assembling them. The criteria chosen so far to respond to this question (sales, employment, computer installations, and trade patterns) provide a macro view of the industry including its relationship with the external world. Chapter six takes a closer view looking at how the criteria selected have shaped the evolution of the industry in Brazil.

5.4 Summary and Conclusions

This section summarizes the main findings of Chapters four and five. The purpose of these two chapters has been to examine the national policy, to compare and contrast it to policies designed to support other sub-sectors of the electronics complex, and to measure the outcomes of the policy by looking at sales, employment, installations and trade.

As a general rule, attempts to evaluate the performance of the informatics industry have given approval to government initiatives. The relevant literature offers substantial evidence that past policies have been instrumental in fostering the establishment and growth of a sizable number of national firms engaged in the design and assembly of computer systems and peripherals. However most do not adequately examine the political environment in which these policies function: they tend to conceal the views of interest groups, and neglect to examine how these may constrain future developments in the sector.

This chapter has illustrated that achievements so far are not sufficient to guarantee the technological independence and autonomy that Brazilian owned firms need in order to compete in domestic and international markets. This is confirmed by the volume of imports and export of Brazilian companies. The policy gave national capital significant advantages in investing in a fast-growing and highly profitable new industrial sector. It hoped to reproduce the necessary conditions to allow them to operate in a 'free' market. Despite this support, the nature of institutional regulation contained the rigidities of a state structure and stood in direct contrast with the fast and volatile changes and the technological dynamism found in digital technology and electronics at large. Thus, expectations regarding the scope and extent of technical/ technological and industrial development exceeded the outcome. The initial objectives of the policy were

ambitious to the Brazilian scale and insulated with political not industrial, technical or scientific power. Also, the priorities set limits of concrete commitment and Brazilian companies opted to take the quickest path to achieving their targets.

But far more important than re-addressing the issues already dealt with by the existing literature, is to see the Brazilian case through the lens of a trans-national industrial complex. This takes Brazil out of the centre of the debate and places it in a framework of a global industrial system, more useful for analytical purposes. This focus reveals that by banning TNCs from operating in selected industrial sectors the national articulation works against the world logic. At the same time, poor support offered to S&T, lack of capitalization and poor coordination of policy programmes for the electronics complex restrain Brazilian firms from the opportunity to become technologically and commercially competent domestically and abroad. Furthermore, given the criteria used in defining the boundaries between national interests and international participation in the Brazilian industry, there is today in Brazil a double market protection. One exists to 'protect' local companies from the multinationals, the other secures for TNCs a monopoly over a large and, in value terms, significant share of the market (the mainframe sector). This double market protection has had different meanings for each side. TNCs are free to carry on doing their business in Brazil and strengthening their foothold in the national market. They faced little increased competition to threaten their position as world leaders (in particular IBM). National companies were left instead with the task of re-inventing the wheel, or rather the micro!

The national electronics and informatics complex is vulnerable on many fronts. Technological vulnerability is serious. The informatics industry has experienced drastic product and process changes every time a new technological achievement in component production or digital technology is made. These transformations have been summarized and discussed in the thesis Introduction. This discussion demonstrates that rapid technological transformations stretch the technological gap between producers (leading firms and the companies which have access to them) and consumers (countries which do not have the technological capacity to reproduce them) neutralize many leap-frogging strategies pursued by developing countries that are unable or unprepared to sponsor similar development programmes. Brazilian-owned companies, in general, have not been able to go beyond increment innovations within well known and relatively open technologies.

Companies have acquired some technological capability in the design and manufacture of systems and peripheral equipment which confirms policy priorities,

given first to the mastering of design and assembly of informatics systems and, in a later stage, the move to the design and manufacture of components and software. The introduction of incremental innovations tends to take place during the initial effort at reverse engineering, enabling companies to copy open architecture products, or once technology is transferred through licencing and by modifying foreign design and specifications to fit local conditions (Frischtak, 1986:23). However, Brazilian firms do not command the resources needed to raise them to new technological levels, through small or significant innovations in system design, components, software, or product processes. Furthermore, when these resources are available they are rarely pooled because of the lack of cooperative ventures among Brazilian firms. The situation is further aggravated when technological dynamism is not followed but is diffused through the institutional framework. Brazil is in many ways at the intersection of these two trajectories. Industrial and institutional restructuring is necessary to cope with economic turmoil -- plant closures, over-production and market saturation -- as well as to overcome the rigidities of national institutional structures. The technological convergence trends in the informatics and other sectors explained in the first part of this thesis demand an equal convergence of national efforts to preserve the existing successes and carry them way into the future. To aggravate matters further, diverging development plans of the Ministry of Communications and Science and Technology, aided by earlier regional development polices to boost the Amazonian economy, are slowly changing the configuration of the sector and accentuating the socio-economic imbalances in the regions where it is found.

Multiple backward and forward linkages tie the informatics sector with other branches of the electronics complex and make it an important input for a number of other 'traditional' user industries. If this view is accepted, and evidence for it is convincing and accumulating, countries are forced to confront and revise emerging conflicting options (Arnold & Guy, 1986). The first problem is how best to use, absorb and implement informatics products and processes to improve productivity and how to make informatics a tool for economic prosperity. Secondly, having chosen to be involved in the production of informatics goods to decide where to concentrate national resources and maximize national control over technology. Thirdly, to revise, formulate and implement strategies that take into consideration the dynamic technological transformations occurring.

The Brazilian model addressed some of these issues. But it has done so in a passive manner, resting on the assumption that a partial commitment to technological

development would suffice and secure the country technological independence.

As to the role of the state, it is certainly true that state intervention (in the form of the market reserve policy), has re-defined the industry's structure and competitiveness from the late 1970s onward. But current concerns have changed and challenged the efficacy of the given policy to achieve its targets.

The following two chapters focus on the local level to examine changes in the geography of Brazilian informatics tied to both global and national political, technological and industrial trends.

CHAPTER VI

VI The Geography of Brazil's Informatics Industry

6.1 Introduction

This chapter, together with chapter seven, examines the geography of Brazil's informatics industry. The aim of these chapters is to offer an alternative view of the impact of the Brazilian Informatics Policy (PNI) on the development of the Brazilian informatics industry. This intersection of policy targets (that is political goals of social and economic development) and existing outcomes (industrial location) gives evidence on "whether regional development amounts to development *of a* region, or merely development *in a* region." (Morgan & Sayer, 1988:6). This difference in development depends not just on the level of industrial activity in a region but also on the character of that activity. Thus, the focus of these chapters is the firms, and the data used is firm based. "Firms create a spatial division of labour between different regions and they perform differently in each context. They have different regional impact in terms of local purchasing and subcontracting, and lastly, different agents benefit in the localities in which firms are set up. It is therefore the combination of all these factors that amounts to a differentiated and highly uneven regional development" (Morgan & Sayer, 1988:7).

The focus of this chapter is the historical development and present social and economic characteristics of Brazilian informatics at a local level. The purpose of the chapter is to reconstruct the industrial geography of the country's informatics and electronics industries illustrating the spatial division of labour between different regions. Four aspects of Brazilian informatics' industrial geography are examined: industrial growth, industrial distribution of producers, regional distribution of users and regional sales and employment.

6.1.1 Structure of the Chapter

The chapter has three parts. Section 6.2 analyzes historical patterns of industrial concentration of electronics companies in Brazil in four different periods from the mid 1970s to 1989. These industrial growth patterns are illustrated in maps 1 to 4. Section 6.3, using available firm based geographical data, examines the aggregate distribution of electronics companies (section 6.3.1), the distribution of industrial users of

computers (section 6.3.2), and regional sales and employment (section 6.3.3). Section 6.4 summarizes and concludes the chapter.

6.2 The Industrial Geography of Brazilian Informatics

This section reconstructs the geography of Brazilian informatics illustrating changing patterns of industrial agglomeration from the mid 1970s onward in four maps. To carry out this task a data base of firms operating in **all** sectors of the electronic complex including mainframes, super mini and minicomputers (group 1), microcomputers and other systems (group 2), peripherals (group 3), parts and components (group 4), microelectronics (group 5), telecommunications (group 6), consumer electronics (group 7), industrial automation (group 8) and instrumentation (group 9) was needed.

The analysis of data including all firms in the electronic complex illustrates the links and complementarities between informatics (producers of computers, peripherals and parts) and other sectors of the electronics complex. This follows a discussion initiated in the Introduction about the electronics complex (section I.3) and corroborated in the discussion of different national informatics policies (e.g., in France, Japan, the EEC experience).

The data used in this section merged three large data bases including 368 companies (of which 168 are in the informatics sub-sector) and relevant information on six variables: year of creation of company, type of capital (foreign, national, joint venture), industrial activity, geographical location, employment, and subcontracting relations (i.e., number of subcontractors). Information was also available on output. However, this variable could not be used given the difficulty of comparing values given in at least three different currencies.

The first data base, compiled and managed by SEI included all firms that have registered with SEI to operate in the sector [1]. SEI also provided an updated 1989 list, which included only those firms that replied to SEI's 1989 company survey. To cross-check the accuracy and completeness of the data I compared SEI's information (data base and 1989 list) with the ABICOMP's and Gazeta Mercantil data bases on industrial

[1] Only firms registered with SEI are authorized (or can legally obtain import licenses) to import electronic components, parts and software needed for the production of products using digital technologies.

producers of electronic products.

The series of maps attached were produced using the data. They show the distribution patterns of electronics companies throughout the national territory prior to 1974, and in three periods after that. Two reference maps are included in appendix 5.

In what follows each map is explained, describing changes in the geography of the industry which have been discussed so far. This discussion of changing industrial patterns illustrates the unevenness of sectoral industrial development in Brazil. According to Smith uneven development is a result of a continuous capitalist search for profit. It will be shown here, however, that in addition to profit seeking motives investors move in and out of different sectors and regions as a result of other equally relevant factors such as technology changes, industrial policies, regional development policies, etc.

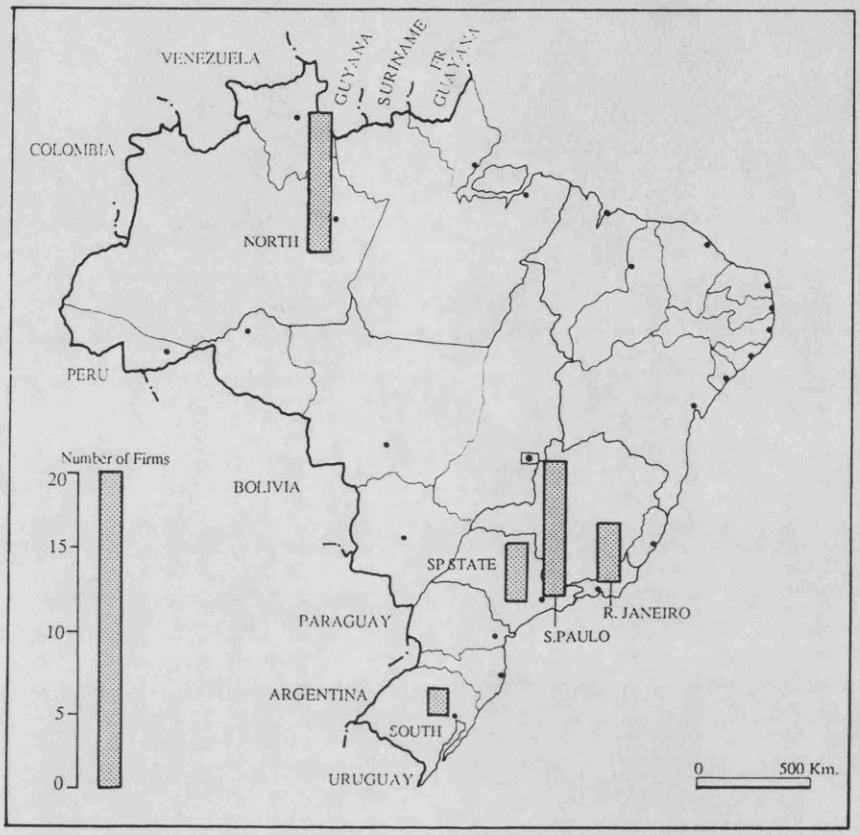
Map 1 - The first map describes the concentration of electronics firms operating in Brazil prior to 1974 when there was no explicit industrial policy for the informatics sector. Firms were located primarily in the South-East of Brazil and in and around the cities of Sao Paulo and Rio de Janeiro. This concentration followed historical and existing patterns of industrial agglomeration that started in the South-East.

The first companies to develop in Brazil were transnational corporations who saw in the country an opportunity to explore local and regional markets. These firms went to Brazil in search of new markets and business opportunities, following a development pattern put forward by dependency theorists like Wallerstein (Larrain, 1989). Table 5.5 in the previous chapter gives the date of creation of most TNC's located in Brazil. The table shows that by 1970 most of Brazilian based TNC's had already opened commercial outlets and/or factories in Brazil.

IBM was one of the first companies to arrive in Brazil. The first industrial operation of IBM, in Benfica, RJ, established in 1939, marked the beginning of informatics activities in Brazil. This was IBM's first industrial plant outside the US, and it assembled industrial clocks, tabulating machines and typewriters (Piragibe, 1985:108). By 1976 the company was assembling its 360/148 systems.

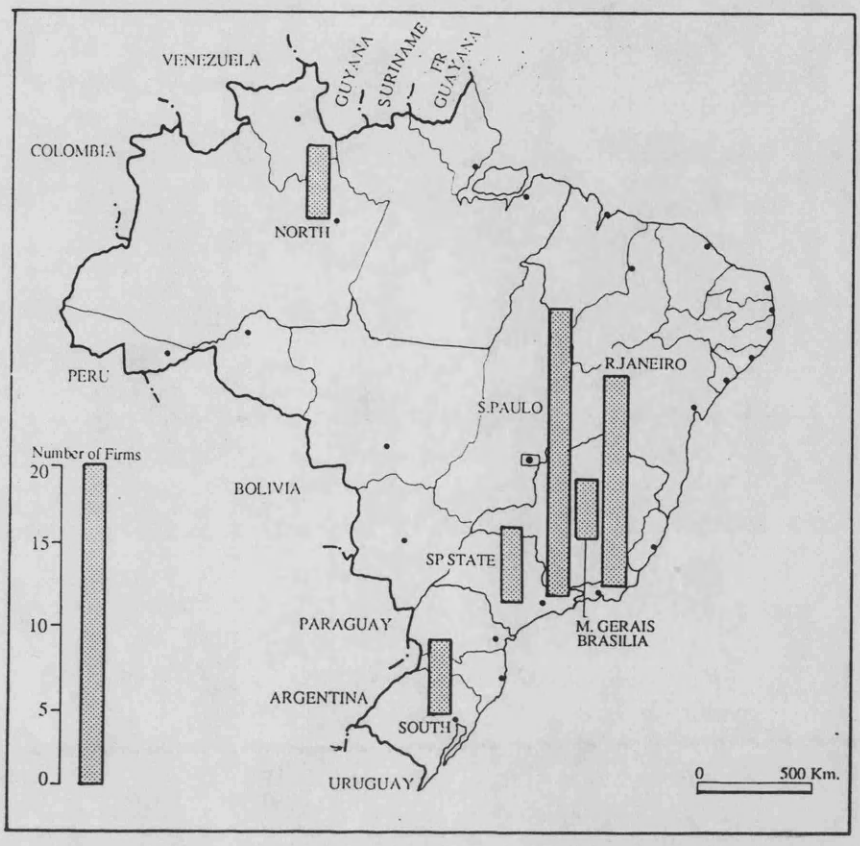
Map 1

Brazilian Electronics - Regional Patterns of Distribution prior to 1974



Map 2

Brazilian Electronics - Regional Patterns of Distribution between 1974-1978



Most TNCs, including IBM, opted for a vertically integrated structure of operations where assembly of products was done inside the company using a high proportion of imported components. Production activities were part of the corporation's international division of labour, thus not favouring either the transfer nor the development of local products and process technologies. These strategies inhibited the diffusion of growth through local purchasing and subcontracting, as investors purchased components from their overseas subsidiaries instead. At the same time, TNCs located in the South-East region did not contribute to any significant increase in the number of firms operating in the sector nor to the development of backward and forward linkages between TNCs and Brazilian suppliers.

National firms operating in Brazil before 1974 were involved in the production of electric components and consumer electronics (radios and TV sets). According to Baptista, these firms operated in the national market and had well developed linkages with other sectors of the economy (Baptista, 1985).

This pattern of industrial development based on the activities of a handful of vertically integrated TNCs dependent on the import of parts and components and their assembly in Brazil, and of national companies equally dependent on key imports coupled with the absence of any form of state intervention to regulate TNC's activities, explained, in part, the slow growth of the Brazilian sector prior to 1974.

Map - 2 This map illustrates changes in industrial concentration from 1974 to 1978 showing an increase in the number of new firms located in the Rio de Janeiro - S. Paulo area, the emergence of the Minas Geraes - Brasilia industrial centre, and the appearance of new firms in the South and in the North.

The increase in the number of new firms was the result of four interrelated factors: 1) the creation of Cobra; 2) the establishment of the Manaus Development Zone in 1967; 3) technological innovations in the manufacture of colour televisions, and lastly, 4) a rising capital liquidity coupled with economic growth.

The creation of the national computer firm Cobra coincided with the passing of government restrictions on imports of informatics goods after 1976. These two events forced TNCs to limit their expansion plans and to consider strategies to circumvent the new regulations. As discussed in Chapter three, these TNCs would probably have followed a model of growth pursued by TNCs in the 1970s which included the location of an assembly plant in a developing country and the commercialization of imported

equipment.

The creation of the Manaus export promotion zone (hereafter ZFM) in 1967 (and the creation of the industrial district in 1972), and changes in the use of solid state technology in television production (1972), affected the structure, composition and industrial location of the national consumer electronics sector. It also paved the way for a new spatial division of labour in the consumer electronics sector in Brazil (Baptista, 1985). The establishment of the ZFM led to a migration of consumer electronic companies from the South-East to the North of the country and the arrival of new firms in the North. Few firms opted to shut down plants in the South-East. However, there is no evidence of any significant deindustrialization on a national level during the period 1974 to 1978.

The creation of an import production zone in 1967 also coincided with the beginning of a period of internationalization of American, Japanese and European consumer electronics companies. These events have been described in Chapter two. Some of these companies like Toshiba, Philco and Phillips found an opportunity to enter the Brazilian market via this import protection zone, and eventually to control the national market.

The fourth factor affecting industrial location during the four year interval (1974-1978) was the changes in the political economy of this sector. From a supply side, the government offered protection of selected product markets; it restricted the activities of TNCs to operate only in the mainframe market and in the production of other goods for exports; and lastly the government offered a range of fiscal benefits and development grants to national capital to enter the sector.

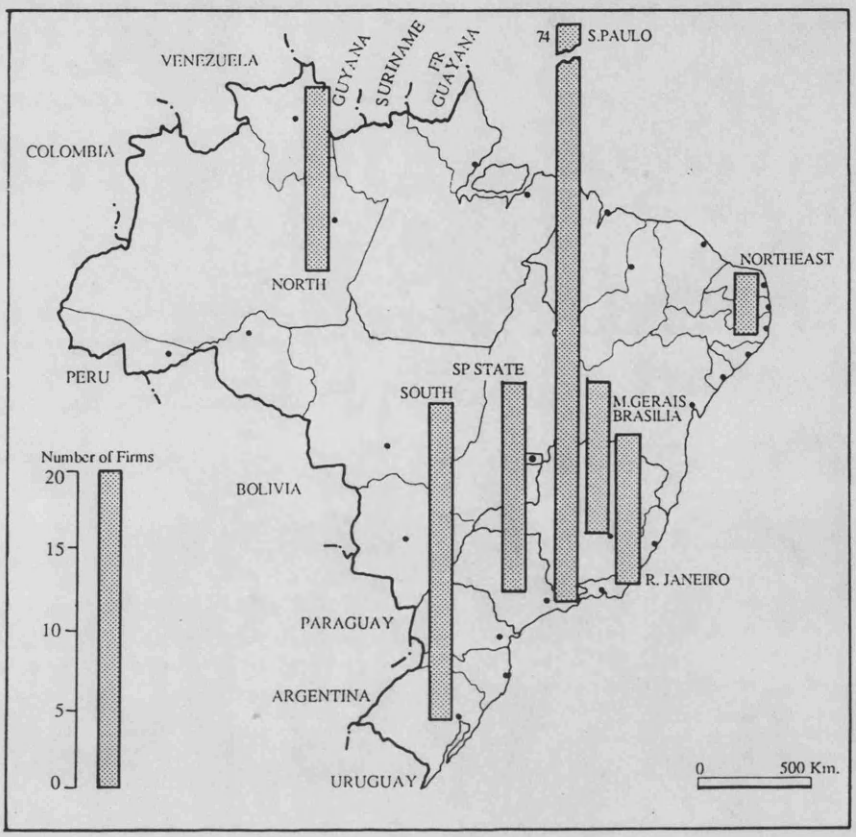
From a demand side, the market for computers went into a total revolution with the appearance of microcomputers in the early 1980s. Internal demands from both public and private sectors rocketed. A greater financial liquidity, the result of years of economic abundance (the Brazilian miracle) followed by first signs of exhaustion of the development model in the late 1970s, pressed national capitalists to look for new investment opportunities (i.e., the case of Brazilian Banks, Chapter five, section 5.2.4). The combination of both external and internal conditions led national capitalists to see in informatics a risk-free investment opportunity.

Map 3 - A sharp increase in company registration and employment occurred between 1979 and 1983, as shown in this map. The reasons for this increase in firm registration were, as in the previous period political, technological and market led.

By 1979, the political campaign in favour of the policy (PNI), and the creation of SEI, formally lowered entry barriers, enabling Brazilian capital to enter the mini and microcomputer markets. Newly formed domestic companies were spin offs from universities and other institutes, or they were new divisions of existing companies operating in the mechanical and electric sectors. These companies tended to locate themselves in the South-East of the country, regardless where they originated, to benefit from a well developed industrial infrastructure. 82% of companies created after the policy (PNI) were located between the S. Paulo and Rio de Janeiro area. Over a period of five years, 52% of the 168 electronics companies established in the country were in the informatics sector alone. Between 1979 and 1986, Brazilian domestic companies grew at an average of 30% per year. Employment, in turn, rose from less than 5,000 in 1979 to over 11,500 in 1986 (SEI, 1989:24).

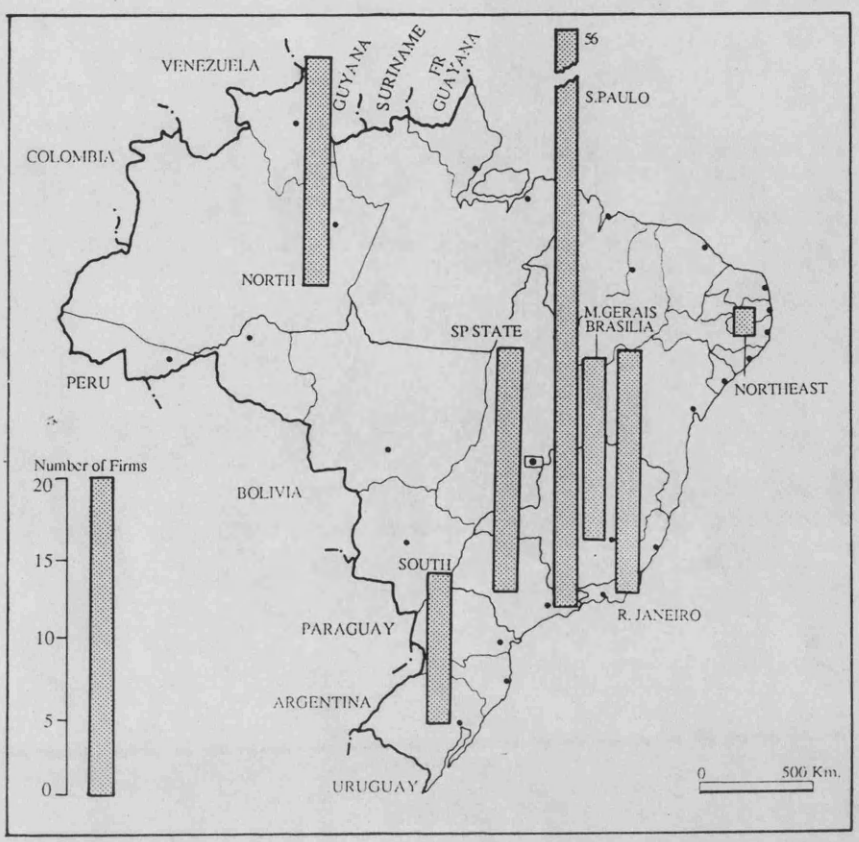
Map 3

Brazilian Electronics - Regional Patterns of Distribution between 1979-1983



Map 4

Brazilian Electronics - Regional Patterns of Distribution between 1984-1988



Map 4 - From 1984 to 1989, the informatics industry continued to experience new challenges with new actors coming onto the scene. A large number of firms were set up in all seven geographical regions, with S. Paulo metropolitan area leading the way in number of registrations (56 new firms). At the same time, the institutionalization of the policy, profit decline, increasingly inter-regional competition, and the instability of the national economy, all affected industrial location during the four-year period.

In the political sphere, the institutionalization of the policy (PNI) into law strengthened the protection and market position of domestic companies vis-a-vis foreign producers. Opposing the stability offered by the policy (PNI) conflicting regional policies such as the export processing zone plan threatened the existing industrial structure, and the regional competition continued between Manaus and the rest of the country.

In the national economic sphere, a succession of crises and booms (described in Chapter four), rising inflation, increasing internal and external debts, made themselves felt in the informatics sector. Economic problems brought down the sector's high growth rates experienced up to 1986. In 1987, profit rates decreased by 15% (Senhor, 26/05/87:48). Employment in the informatics sector alone experienced a slight decrease from 31,021 (1986) to 30,947 (1987), of which national employers were responsible for 1000 job losses (SEI, 1989:24). Companies like Cetus, Embracom, Polymax, Flexidisk in the South-East, and Dismac in the North filed bankruptcy, and capital investments were greatly reduced (Veja, 24/06/87:115).

In the technological sphere, unrealistic promises to support and train a national labour force, the scarcity of S&T resources (Chapter four, section 4.4), the difficulties of developing indigenous products (reinventing the wheel), high costs with process and product development production costs[1], and illicit industrial practices, such as contraband (Chapter five, section 5.3.2.3) decreased the possibilities of Brazilian domestic companies achieving many of the desired technological goals set out by the law and the informatics plan - Planin.

The newly established science parks influenced regional distribution of firms throughout the country. Santa Rita do Sapucaí, in Minas Geraes, Campina Grande in Paraíba, and Fortaleza in Ceará, emerged as new industrial zones catering to

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[1]Tigre & Perine, 1984:4. For more on price differentials see Piragibe, 1984 and Hewitt, 1988.

technology intensive industries. Other traditional areas (e.g., Rio de Janeiro, Curitiba, Campinas), adopted the concept as a mechanism for industrial restructuring, trusting the potential for growth of the industry and its multiplying effects on the region's economies (Pereira, 1987).

6.2.1 Summary

In short, these maps illustrate the contributions of the PNI on Brazilian industrialization. In absolute terms, and shielded by the national informatics policy, 168 informatics companies were established, and over 30,000 jobs in informatics created with multiplier effects throughout the country, and another 200 plus companies and 90,000 jobs were created within other sub-sectors of the electronics complex [1]. The maps portray a positive and significant growth of firm registration in different parts of the country. The impetus behind such growth was profit. Different capital groups (TNCs, national firms) and industrialists operating in different sectors (informatics, consumer electronics, components) behaved differently to realize their business goals. The formulation and approval of the national policy facilitated the emergence of a national informatics industry. TNCs that came to Brazil before industrial regulation sought ways to circumvent the national informatics policy and maintain their market shares. The creation of the Manaus Export Zone coincided with significant technological change in television production and promoted the development of a new industrial area in the North and attracted the business of large TNCs operating in the consumer electronics sector.

Similarly to the analysis of sales, employment and computer installations, these maps portray an aggregate and positive picture of industrial growth. They do not show, however, the types of relationships between companies within and between regions.

To complement the information given so far about changes in industrial location of informatics and other electronics firms, the next sections examine other types of geographically specific data. This information is limited, covering four aspects of the industry's geography:

1) the distribution of firms per sub-sector in the national territory;

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[1]In 1988 total employment in the electronics complex was 68,264, in services, 61,351 totaling 129,615 (SEI, 1989:14). These figures exclude consumer electronics.

2) the regional distribution of computer users;

3) regional sales and

4) employment.

The first set of data is based on the 368 amalgamated company data bases of SEI and Gazeta Mercantil which were used to produce the locational maps. The second is based on Dados & Ideias' 500 largest users of informatics. The third and fourth, regional sales and employment are provided by SEI.

6.3 Misleading Geographies

6.3.1 The Industrial Location of Producers

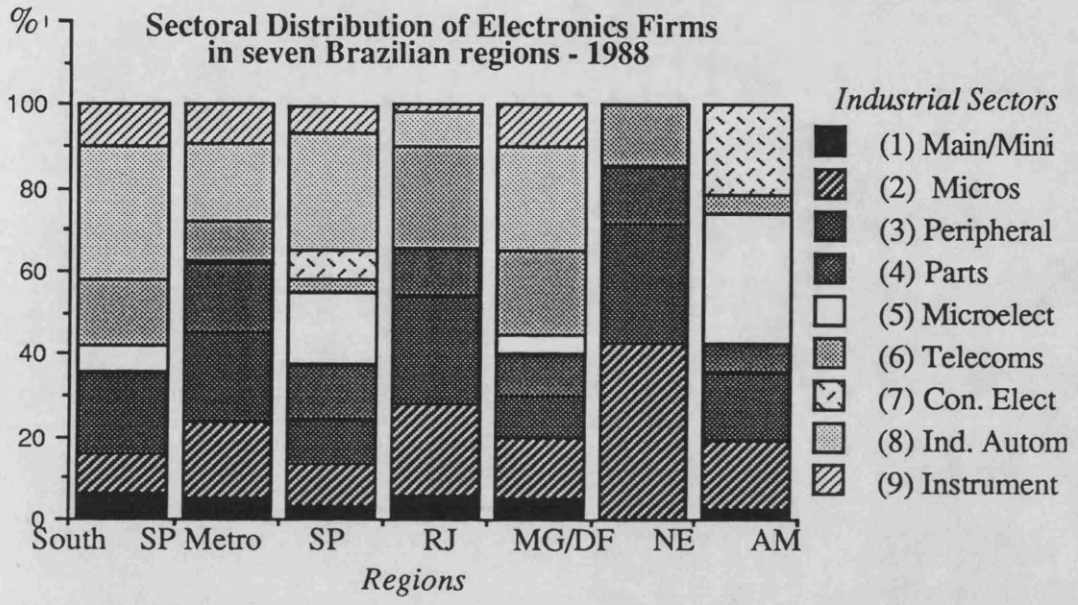
The purpose of this section is to find out who produces what and where in the national context. This section complements the four maps and it is based on the same source of information.

Following the patterns of concentration illustrated in the maps the data was divided into seven areas. These were: 1) the South comprising the states of Rio Grande do Sul (RS), Santa Catarina (SC) and Paraná (PR); 2) The S. Paulo metropolitan area (Greater SP); 3) the S. Paulo state (SP); 4) the Rio de Janeiro metropolitan area (RJ); 5) the state of Minas Geraes (MG) and Brasilia (DF); 6) the North-Eastern (NE) region comprising the states of Bahia (BA), Pernambuco (PE), Paraíba (PB), and 7) lastly the Manaus region (AM). (See locational map in appendix 5) The metropolitan areas of Rio and S. Paulo are considered individual units given the massive concentration of companies, services and buyers.

A breakdown of the total number of registered firms prior to 1974 and between that date and 1989 reveals a concentrated pattern of specialization and spatial division of labour amongst national regions. The two figures below show the spatial distribution in two distinct ways.

Figure 6.1 shows the sectoral distribution of companies in the seven national regions. The figure illustrates the degree of industrial diversification/specialization in each of the seven regions. A darker shade has been used to distinguish the concentration of informatics firms from other firms in each region.

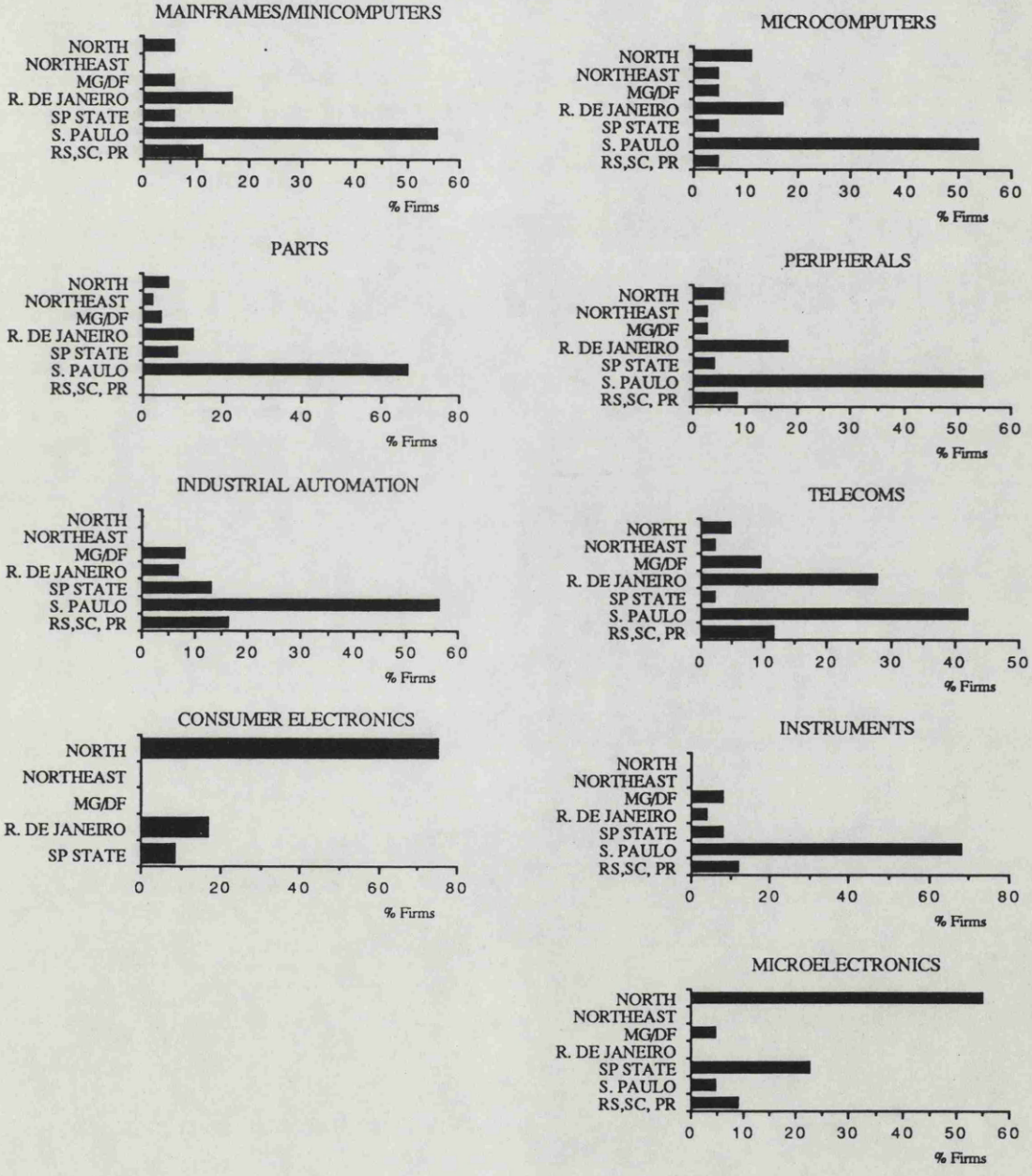
Figure 6.1



** Darker shades represent the industrial sectors of the informatics industry proper.*

Figure 6.2 illustrates the regional distribution of companies according to nine industrial sectors (Mainframes and minicomputers, microcomputers; peripherals; parts; microelectronics; telecommunications; consumer electronics; industrial automation and instrumentation).

Figure 6.2



The two figures complement each other. The nine industrial sectors are unevenly distributed throughout Brazil. Consumer electronics, for example, is found only in the SP and Manaus area. This sector represents 78% of the total number of companies

operating in the ZFM. Microcomputer producers are also in Manaus (12% of total number of producers in the country) in spite of the battles between SEI and SUFRAMA to remove import facilities from computer companies located in the area.

Industrial automation and instrumentation are two relatively new sectors in Brazil, and are domestic companies, concentrated in the metropolitan area of S. Paulo and S.Paulo state. 75% of all industrial automation companies and 80% of all instrumentation companies are located in the metropolitan area of S. Paulo. The former is also present in the South (16.1%) and in the Central area (9.6%). In the South and in Minas Geraes there is a concentration of Brazilian based companies of varying sizes and with a range of industrial activities producing for local and regional markets.

The North-East region is at the bottom of the list when it comes to electronics companies. With only 1.5% of the total number of companies in the country, North-Eastern companies are almost entirely detached from the industry's national division of labour.

A buyers market is concentrated around Brasilia where the federal government is located, and producers are concentrated in the Belo Horizonte, Sul de Minas regions: 5.6% of all national companies are located in these two localities. Chapter seven pursues this discussion of industrial location, looking at the economics of location of firms.

6.3.2 The Location of Users of Informatics Products

The second type of geographically specific data includes regional sales and distribution of computer users nation wide. This data shows where the markets are. While this thesis is primarily concerned with production, this is useful indicator of informatization (greater use of information technologies) in the country.

This analysis is based on data on the top 600 industrial, commercial and public users of informatics goods in the country, and the types of system configurations they have at their disposal. The data base included only large central data processing offices within companies and government institutions, the numbers of mainframes or minicomputers, microcomputers available to each of them, the types of application used and the types of data processing operations performed by these centres.[1]

Figure 6.3 shows the total number of data processing centres (566) in 18 states

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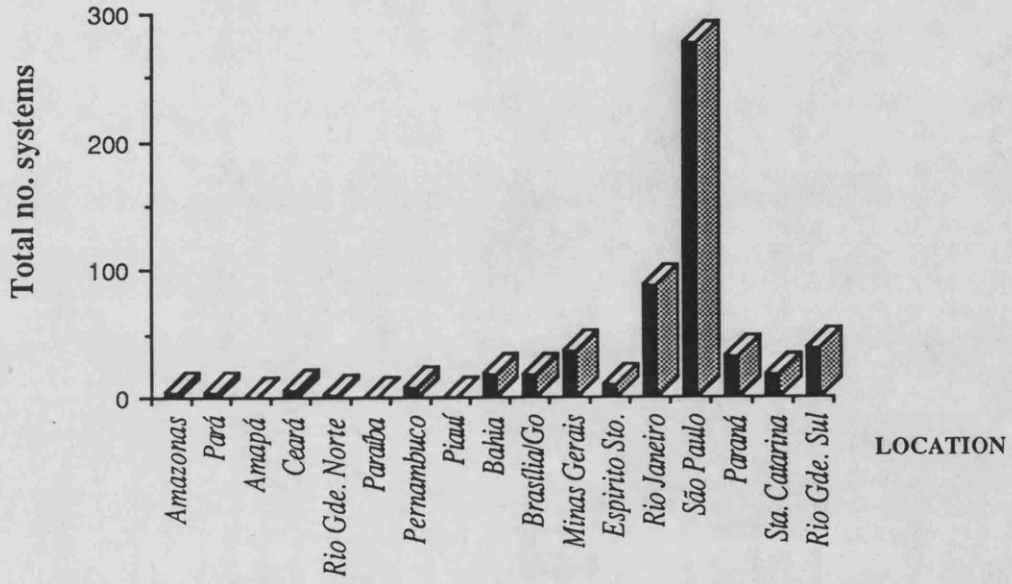
[1] ***Dados e Idéias***, no.126, Nov/Dec 1988 "As 500 Maiores Empresas Usuárias de Informática."

of the nation. As the figure illustrates, 49% of all data processing facilities in the country are located in S. Paulo. The state is followed by Rio de Janeiro (16%), Rio Grande do Sul (6.9%), Minas Geraes (6.4%) Paraná (5.7%) and Brasilia. The North and North-East are poorly represented with few data processing centres.

Figure 6.3

Regional Distribution of Installed Computer Systems in Brazil, 1988



Source: Adapted from Dados & Ideias (1988)
"As 500 Maiores Empresas Usuarias de Informatica."

Table 6.1, in turn, illustrates where data processing facilities are located both within states and within economic category.

Column A (% national distribution of systems per industrial sector) shows that computers are widely used in the 18 sectors listed. Sectors with a greater concentration of computer users include food processing and petrochemicals (7.6%), electro-electronics (industry and services) (7.3%), retail, civil construction and financial institutions (6%).

These patterns of computer use based on company informatization must be put into perspective. The survey includes only large computer users and excludes smaller companies. Thus the sample is biased towards TNCs, state companies and large Brazilian corporations. At least 39% of the companies listed are Brazilian subsidiaries of TNCs. Another large proportion are Brazilian state owned companies (18%), and

most of the remainder are in the hands of producers of the country's most important export products such as orange juice and pulp, agricultural and meat products, leather, military and defense, metallurgy, petrochemicals and civil construction. Moving away from public users, TNCs and major exporters, come large national companies producing consumer goods for the internal market (e.g., clothing, beverages, furniture, retailing, motor vehicles), and in service provision (e.g., transports, private banks).

These data indicate, nevertheless, the extent of informatization of the public sector, which includes the public banking system (national and state banks), public services companies (electricity, telecommunications, transports.), all federal agencies, and naturally, big state companies, key representatives of the state procurement strategy (e.g., Petrobras, CSN, Vale do Rio Doce).

To conclude, the distribution of users of informatics goods demonstrates that computers are already in use by companies operating in 18 different economic sectors. As for the regional distribution of installed systems, the South-East region has the largest numbers of computer producers and users. Other regions of the country, including the North and North-east and Central regions have production facilities, but do not have developed computer user markets.

Table 6.1

State Locatio	AM	PA	AP	CE	RN	PB	PE	PI	BA	MG	ES	RJ	SP	PR	SC	RS	DF	GO		%
																				Nac.
Category																			Total	
																			column	A
Agriculture			1							1			5	9		4		1	21	3.7
Food Processing				1		1			3		1	4	26	1	3	3			43	7.6
Light Manuf													19			2			21	3.7
Beverage/Tobac							2					5	14	1	1	2			25	4.4
Commerce				1			1	1	1		1	14	13			2	1		35	6.2
Construction				1					4	5		9	11	1			6		37	6.5
Elect/Electronic	4									2		4	26	1	1	2	1		41	7.3
Finance				2			2		3	1			18	2		3	4		35	6.2
Purniture/Tim		1									1		11	3	1	4			21	3.7
Vehicles									1	1		10	15			4			31	5.5
Mechanics	1									3		2	21		1	3	1		32	5.7
Ferrous Metals									1	7	1	3	13	1		1			27	4.8
Mining		2			1				2	5		4	5		2	1		1	23	4.1
Non Ferrous M										4	4	4	17	2			1		32	5.7
Paper/Pulp										1	1	2	13	5	1				23	4.1
Petrochem									1	1		12	25			4			43	7.6
Public Serv				1					2	2		10	6	2	3	2	3		31	5.5
Textiles/Cloth					1		2			2		6	12	3	4	3			33	5.8
Transports										1	2	3	6						12	2.1
Total Systems	5	3	1	6	2	1	7	1	18	36	11	92	276	31	17	40	17	2	566	100
% national Dist	0.9	0.5	0.2	1.1	0.4	0.2	1.2	0.2	3.2	6.4	1.9	16	49	5.5	3.0	7.1	3.0	0.4	100	

REGIONAL DISTRIBUTION OF COMPUTER INSTALLATIONS IN BRAZIL IN 19 ECONOMIC SECTORS - 1988

6.3.3 Regional Sales and Regional Employment

This section looks at regional sales and jobs and it is based on SEI's data.

SEI measures regional sales according to the amount of items purchased by each region. These items include only computers, peripherals, and parts. S. Paulo and Rio de Janeiro are the largest markets having bought 43% and 17.2% of all sales in the country in 1987 (Table 6.2). The Minas/Brasilia region fluctuated between 8% and 15%, thus confirming the role of government as one of the largest consumers of informatics goods in the country. A sharp increase in sales from 4.8% to 11.3% between 1979 and 1980 in the South coincided with a successful regional campaign to attract informatics companies to the region, including the creation of science parks in three Southern states, and most importantly, for existing Southern based companies to move into the sector. The North-East remains a residual market in the country, reflecting the lack of major users, and other producing companies.

Table 6.2
Distribution of Sales of Informatics Goods per National Region

Areas/yrs	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*
S. Paulo	39.4	42.7	41.6	33.7	31.3	37.1	42.7	42.1	43.0
R.Janeiro	29.1	33.2	29.6	24.5	26.4	20.3	17.7	17.7	17.2
SP State	-	-	-	6.5	15.1	11.0	9.8	9.8	8.8
DF/MG	8.8	8.1	10.1	14.7	9.9	10.8	11.2	11.2	13.1
South	4.8	11.3	13.3	14.0	10.4	12.5	11.01	11.01	10.4
North-East	-	-	-	4.1	4.2	4.7	4.6	4.6	4.12

Source: SEI, 1986:40; SEI, 1989:34

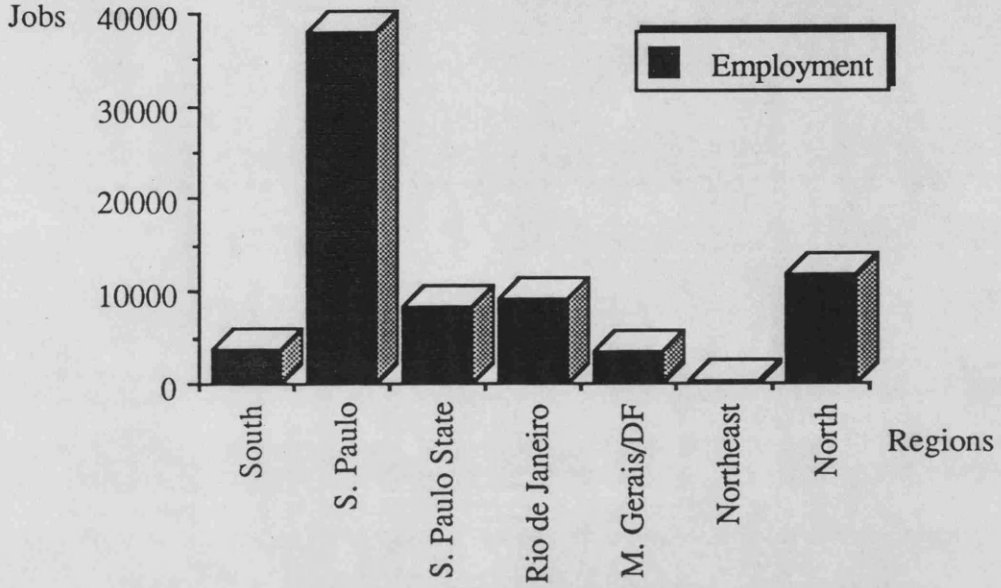
The last set of data indicates employment figures for each of the seven regions, in 1988. These are presented in Figure 6.4. These data, together with the information presented in the maps, most clearly illustrate the position of capital and labour in the national territory.

SEI's employment data is limited. The annual company survey used by SEI does not require informants to provide geographically specific employment data. To illustrate: IBM employs 4,500 people, 2,700 of whom work in its Sumare plant near S. Paulo. However, employment figures are usually included in those of Rio de Janeiro, and sometimes Brasilia, where the headquarters and main offices are. The same occurs with the largest national conglomerates like Itautec, Elebra and Sid which have branches

located in more than one city and state, and yet employment figures are totalled for the company and included in those of one area.

Figure 6.4

Regional Informatics Employment, 1988*



* Employment in the Manaus area is 1985 data (Hewitt, 1988)
Source: Own research, 1989

6.4 Summary & Conclusions

To conclude, the purpose of this chapter was to map out the geography of the Brazilian informatics industry in the broader context of the electronics complex in Brazil. To do that four angles of the geography of Brazil's informatics industry were examined. These included growth and distribution of electronics firms in the national territory, regional distribution of computer users through 18 economic sectors, regional sales, and employment.

The major findings of the chapter were first, to illustrate with four thematic maps, the convergence of often competing industrial growth patterns and industrial policies, and the development of the electronics complex in different parts of Brazil.

Second, the impetus behind such growth cannot be reduced only to profit making, as Smith would argue, and as it has been argued in government reports and other specialized literature (SEI, 1989). Certain events have had a clear impact on the location of firms in different parts of the national territory. These events included the approval of a national policy for the informatics sector, the creation of a national company - Cobra, and the formulation and approval of competing regional policies.

Other events which have affected the location of firms in Brazil have had most impact elsewhere. These include, for example, technological innovation and change first in televisions (affecting the relocation of consumer electronic industries from the South-East to the North), and then microelectronics (leading to the appearance of the microcomputer).

Third, the global economic crisis in the late 1970s (and discussed in Chapters two, three and four) also had an impact at the national level. First, many TNCs began to relocate their activities to developing countries like Brazil as a profit seeking strategy. Many of the firms that came to Brazil were in the consumer electronics sector, others were in the informatics sectors. Once established in Brazil these firms did not move . They chose a location that suited their needs (proximity to ports and airports, in or near major urban centres, well served by transportation, communications, public services). In spite of rigid and flexible industrial policies (for informatics and consumer electronics respectively), TNCs encountered no barriers to carrying out operations in Brazil in line with their headquarters strategies.

Lastly, the chapter explained how the geography of Brazilian informatics has gained through the policy (PNI). Maps 1 to 4 show the steady growth of firm registration throughout the country over a period of 20 years. These geographical changes, however, give only an aggregate image of the geography of the industry in Brazil. The next chapter goes beyond the aggregate picture focusing on the relationships between firms and localities on the local level, and the relevance of these relationships for a sustained development of this national industry.

CHAPTER VII

VII Industrial Location of Informatics in Brazil

7.1 Introduction

This last empirical chapter complements Chapter six in examining the geography of the national informatics industry. Using the same geographical distribution employed in Chapter six this chapter examines linkages between firms and localities, the types of policies used to promote this sector in different parts of the country, and how these have been shaped and affected by local conditions.

Most of the data in this chapter results from interviews with key individuals working in firms and other relevant institutions. Other relevant information includes company reports, answers to the survey questionnaire, and available material on science parks. For the sake of confidentiality, companies are identified by letters rather than their real names.

7.1.1 Structure of the Chapter

The chapter has two parts. The first focuses on industrial clusters in six Brazilian regions: 1) S. Paulo and S. Paulo state; 2) the Rio de Janeiro Metropolitan Area; 3) the South; 4) the North-East; 5) Minas Geraes and Brasilia, and the Manaus area. Each region is examined with the following criteria: the structure of the local informatics industry, the presence of backward and forward linkages between companies, the impact of different forms of regional assistance on local development, and the links between the region and other national and international players.

The policy for export production zones in Brazil is examined in section 7.2.7. This theme deserves particular attention as it was originally planned under the national informatics policy, and if approved, could become another major competing development policy regulating high profitable sectors like informatics. Section 7.3 summarizes and concludes the chapter.

7.2 The Electronics Industry in Brazil: Regional Patterns

7.2.1 S. Paulo, S. Paulo State

The South-Eastern corridor is the most important industrial region in Brazil, and

as was demonstrated in Chapter six, is also the centre of the national informatics industry.

As noted in Chapter six, a total of 189 firms were registered in the region in 1989. This figure represented 55.6% of all mainframe and minicomputer producers; 53.8% of microcomputer producers; 54.8% of peripherals; 66.7% of makers of parts and components; 41.9% of data communication companies; 56.5% of the industrial automation sector and 68% of the instrumentation sector. Seven of Brazil's largest informatics conglomerates are located in S. Paulo (Elebra, Itautec, Sid, Scopus, Digilab, ABC Bull and Multitel). In 1988 there were 37,870 people employed by the industry[1], or 50.5% of the total electronics employment in the country. Nearly 5,000 technical support personnel, or 57% of all technicians were employed in the region (SEI, 1989:133).

Firms located in the city of S. Paulo also benefit from an infrastructure stretching out over a 200 km radius including research centres, universities and industrial facilities of many companies with headquarters located in S. Paulo.

This region has a complex and well defined spatial division of labour including a military defence complex centred in S. Jose dos Campos and a major university based R&D centre located in and around S. Paulo and Campinas. In sum, this region is at the forefront of industrial and technological developments in Brazil providing both TNCs and national companies with a well developed business (developed services) and industrial (multi-sectoral industrial parks) environment required by investors.

S. Jose dos Campos is one of the largest and most developed cities in the area located 90 Km from S. Paulo with a population of half a million people. The city is also the centre of the Brazilian military defence industry with the presence of Embraer and Avibras, producers of civil and military aircraft, and of the Aerospace Technical Centre (CTA) and its four institutes including an university (ITA) and three R&D centres of the Air Force (IPD, IAE, IEA). Another five hundred companies are based in the municipality, employing 25,000 people.

The second largest city in the state, Campinas, with one million inhabitants, is an important research centre with three leading state R&D Centres: CPqD (Telecommunications), CTI (informatics) and Sincotron (Nuclear accelerator). There are two major universities: UNICAMP and Puc Campinas with a population of 4,000

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[1]Figure reflects total employment in 1988 of the 368 firms listed in the data base (73,000).

post-graduate students. Some of the largest national and international corporations are in Campinas totaling 1300 industrial companies and 70,000 jobs. At least 40 companies operate in the electronics sector. They are distributed as follows: 5.4% in microelectronics, 29% in telecommunications, 15% in computer production and 15% in instrumentation. Important companies include IBM, Hewlett Packard, Fairchild, Elebra Microelectronica, Digilab and PHT.

Firms located in the region vary in size from very large (more than 1,000 employees) and a large number of small firms (less than 50 employees). Of the total number of 189 firms: 0.5% had more than 1,000 employees, 14.3% had between 999 and 300 employees, 24% had between 299 and 100, and the rest employed less than 100 workers. Most firms (34%), however, were small.

Inter-firm commercial transactions were quite high in the area. This was done by looking at subcontracting contracts between companies. Two types of subcontracting arrangements used by national and Brazilian based TNCs were most common. These included commercial and specialized subcontracting.

Brazilian based TNCs, as has been discussed in Chapters four and six established themselves in Brazil before the existence of a national informatics industry. Up to the mid 1970s the national industry was very dependent on the activities and technologies introduced by TNCs. After the institutionalization of the policy, (PNI) companies were forced to seek ways to circumvent policy barriers and to meet new guidelines stated by the government. One key element of new government demands was for an increased use of national suppliers and services (import substitution). Commercial subcontracting was,therefore, a scheme that permitted TNCs to identify national suppliers and provide them with the necessary know-how and inputs, in exchange for product. This type of subcontracting also had other advantages, including the possibility of reducing production costs when and where cheaper and less skilled labour was available. Of all TNCs operating in Brazil, IBM had gone further in establishing a well developed network of subcontractors in the S. Paulo region. At the time of field work, the company had over 420 suppliers with 291 active ones listed on its roster.

To identify these firms, IBM created an International Procurement Office (IPO) to select potential suppliers to sell to IBM Brazil and other foreign branches of the corporation. IBM and IPO offered these companies production support services and

legal advice on commercial transactions. The initiative, according to two companies selected to participate in the scheme, allowed Brazilian producers to contact potential foreign buyers, and to familiarize themselves with the international market. These factors were highly regarded at a time when the country was going through a period of economic uncertainty.

On the whole, the key criteria used by TNCs for the selection of subcontractors was an attractive quality/performance/price ratio that made local sourcing an alternative to imports. TNCs also enjoyed a privileged position vis-a-vis their subcontractors with respect to their demands. Most of the process technology used by these companies had already been tested and used elsewhere. TNCs were therefore able to provide subcontractors with a support structure, appropriate documentation, staff training and a captive market.

Questionnaire and interview replies indicated that Brazilian based companies operating in the region were also equally engaged in subcontracting arrangements with other companies primarily of the same region. National companies relied on local suppliers as one way to circumvent economic (inflation and economic plans) market instability and risk. This was particularly true for smaller companies operating with shorter term production plans, with limited production capacity, few trained staff and little cash.

Subcontractors produced a diversified list of inputs, including mechanical (components for disk drivers and printers), electric (cables and plugs), electronic (boards) and structural parts (carcasses for monitor, keyboards and cpu's, covers, mats, brand labels).

Subcontracting relationships between national companies were limited only by potential changes in the global divisions of labour. Instead, they were more exposed to the economic volatility and fragility of the domestic market, as demonstrated by the experience of company **A**.

Company **A** used to do most of its manufacturing in-house. After experiencing difficulties in developing products, and in dealing with day-to-day routines of production, **A** decided to work as a systems integrator, that is putting together machines of different makes and selling them as complete systems. To do that, the company purchased the entire system from between 14 to 57 different suppliers after receiving a customer's order and specifications. According to **A**, most of its suppliers were also dependent on

other producers to get their products ready for delivery. In order for this complex chain of suppliers to work properly, production and exchange transactions had to operate in equilibrium, which was particularly difficult. During the Cruzado Plan, for example, the company was able to sell only two complete units/month. This corresponded to an almost 90% reduction in the firm's sales of 20 units/month. In spite of these difficulties and risks, A still preferred to operate as a system integrator rather than resume its previous role as a manufacturer.

A's experience was shared by many other companies. Between 1987 and 1989 poor company-supplier interactions was one of the most important problems faced by the national industry affecting both national and international firms big and small (SEI, 1989). The volatility of the national economy was the first problem listed by industrialists when commenting on their commercial transactions. According to SEI's staff, smaller companies were faced with a double burden: they lacked capital to finance their operations and could not cope with very rapid inflationary periods. Companies complained about suppliers' irregular and faulty delivery patterns and the inferior quality of products. Together these problems made sourcing one of the most difficult problems faced by the industry (SEI, 1989:93), which in turn reflected on the national capacity to carry out a complete process of technological development, transfer, adaptation and diffusion.

Another important indicator of firms' performance and integration with other national and international players was export activity. Linkages between Brazilian based firms and foreign buyers (other than Brazilian based TNCs) were very weak. Practically all exporters were operating in the S. Paulo region. IBM and Unisys together responded to 97.6% of the sector's exports in 1986 (US$231 million) (SEI:1989:34). Most of these exports were to the United States. Domestic companies tried to export but were not so successful. Their activities corresponded to 2.4% of all exports in 1988. Brazilian based companies' export markets were in Latin America (7.8% of all export sales to Argentina and Mexico) and Asia (3.5% of all export sales to China). (SEI, 1989:35).

Firms operating in sectors other than informatics were, on the whole, more successful in their export activity than those producers of computers, parts and peripherals. A visit to two national companies operating in the digital instrumentation sector illustrated how the national informatics policy favoured industrial sectors which

were primarily controlled by national firms. Companies **B** and **C** (with 80 and 150 employees respectively) began their activities in 1984 producing and selling equipment (digital instruments) in the national market. By 1988 the two companies alone accounted for 96% of the sector's exports. Their market was primary restricted to Third World and developing countries including Angola, Nicaragua, Argentina and Colombia. Their success was related to two factors: the market reserve (PNI) barred TNCs from operating in the instrumentation sector, and the absence of high import tariffs imposed by other Latin American buyers, (which was in direct contrast with the case of computer and peripherals).

Another factor that made S. Paulo a desirable and successful location for informatics firms (and others) was the close proximity to research centres. As noted in Chapter two, one strategy used by companies in both the AICs and NICs case was to seek financial and technological support from government, higher eduction institutions and private investors as, for example, was tried in several programmes under the auspices of the EEC.

On the whole industrial collaboration and cooperation programmes between and within NICs have been limited, if not mostly restricted to multilateral initiatives funded by organizations such as the UN (Beer-Gabel & Conquy, 1984). In the case of Brazil initiatives were mainly restricted to programmes being generated in and for S. Paulo's regional market. The region led the country in the number and diversity of collaboration and cooperation programmes between university and industry. 1988 data for Campinas showed that 45% of the companies enrolled in CIATEC, the local science park, maintained some form of cooperation with research institutes in UNICAMP. 28% of the companies worked with the Ministry of Telecommunications Research Centre (CPqD). Elebra Telecom, for example, produced together with CPqD and UNICAMP its electronic switch TROPICO used in the national telephone network systems by Telebras, the state telecommunications company. CTI, the federal informatics R&D centre was also active in microelectronics R&D. The centre bought an encapsulating and mounting IC line from Burroughs and, together with national producers, worked on the development of appropriate process and product technologies. Sid, which in 1988 was the fifth largest informatics company in the country joined effort with 10 research institutions located in and around the S. Paulo area to develop the project ESTRA. The objective of the project was to develop different software prediction environments

(SID interviews). UNICAMP and Itautec worked together in the development of a system to generate circuit boards.

S. Paulo based institutions and scientists were also heavily involved in basic R&D in strategic areas such as data base systems, software engineering, microelectronics, local area networks, computer graphics, parallel processing, artificial intelligence and supercomputing (Info, Aug 1989:25). Concurrent with views expressed in Chapter four regarding national support to science and technology programmes (section 4.4), the quality of the research and the results achieved varied from sector to sector. Staff identified the main problems in carrying out research programmes effectively as a lack of trained staff, lack of funds and lack of state-of-the-art equipment. Senior researchers at recognized centres such as CTI in Campinas and the LST at the University of S. Paulo argued that their institutions and research work were the victims of the national informatics policy which restricted the importation of essential research equipment and hampered the process of technology acquisition, transfer and adaptation in the country.

Companies located in the S. Paulo area benefitted from regional assistance provided by three science parks established in the state. In addition to CIATEC located in Campinas, both S. Jose dos Campos and S. Carlos had such formally established organizations. The S. Jose based park was primarily geared to activities in the military defence complex serving a large concentration of firms operating along the three largest corporations (Engesa, Avibras and Embraer) employing 17,000 people. In the S. Carlos park, informatics represented 10% of the total number of science intensive companies located in the area. These companies were entitled to a range of benefits (municipal tax levies) and technical support from the University of S. Paulo, S. Carlos Campus, and the Federal University of S. Carlos (UFSCar).

Another important feature of many of the largest corporations located in S. Paulo was the concentration of corporate decision making (and therefore control over the firms' internal operations) inside the region.

D was a Brazilian company established in 1981 with the support of one of the largest private banks in the country. **D** was a holding company of a group of five other companies operating in microelectronics, office equipment, computers and peripherals, circuit boards and surface mounting device integrated circuits. **D** had a partnership with another large Brazilian company **E** to produce printers and a joint venture project with

IBM in software development and computer technology licencing. In 1988 **D**'s parent company acquired a major producer of consumer electronic goods in the country and was taking over the microelectronics division of company **E** to become probably the largest national group on microelectronics.

D began as a producer of microcomputers and then diversified into office automation (copiers, facsimile), banking automation (ATMs, CPUs, cash dispensers), commercial automation (electronic cash registers, supermarket laser scanners), peripherals (hard disks and printers), data communication systems, minicomputers and a range of microelectronics devices. **D** recognized that it should bring together technical skills developed in various divisions so to facilitate problem solving and dissemination of results. Thus, **D**'s business strategy was, according to the company, based on an accumulation of efforts and resources to dominate and control production and process technologies from the most simple to the most complex equipment. **D** was organized in large units (4,500 workforce on five different industrial sites -two in the Amazon and the rest in S. Paulo) with a network of 23 sales points in 15 states. 12.3% of the company's work force was involved in R&D and most of these were in S. Paulo. 30% of the work force had university degrees and over 80% of them were between the ages 18 and 30. **D** had offered a range of in-house and external training programmes to staff including management courses, technical support and assistance, language training and overseas technical training. These programmes were designed to make up for the gaps in state support to S&T programmes, and for the poor technical and research knowledge of new graduates. This commitment to R&D brought **D** good business results. **D** introduced to the Brazilian market the 286 chip, laser scanners, copiers and communication control devices. In 1988 the company invested 15% of its total investments in R&D and human resources. The company's modern management methods and employment policies, introduced to build a corporate identity and a nationally recognized trade mark for Brazilian computers, was based on a programme of 'total quality and total solutions'.

Company **E**, in turn, had stakes in all sectors of the electronic complex with the exception of consumer electronics. **E** was organized as a conglomerate. Each division had total control over management/labour relations and production whereas investments were made at the corporate level. In contrast to **D**, **E** opted for this decentralized approach of industrial organization relying on a network of suppliers and concentrating

its resources on the most crucial aspects of technology, administration and marketing.

Both **D** and **E** were model national companies committed to the principles of the national informatics policy and determined to establish themselves firmly in the national market. After 1986 these two companies sought to restructure their operations seeking a greater concentration of resources to maximize their business opportunities. This process focused on improving management, production and marketing as a way to cope with economic problems and to strengthen their market position. It included a growing awareness of customer needs by improving the firm's support services. These innovative characteristics differentiated large Brazilian firms located in the area from other, smaller companies.

In short, industrial location and concentration in S. Paulo started in the late 1920s and developed to become the largest and most complex industrial area of the country. Following this tradition, many companies which now operate in the informatics sector were set up or moved into the region to take advantage of new business opportunities created by information technologies. The contributions of this new industrial complex amount to absolute increases in the number of firms, jobs and revenues, and in relative terms (establishment of backward and forward linkages with other sectors of the region's economy) to the region's development. This contribution was differentiated across technological areas (e.g. technological competence in the production of simpler computer architectures) and markets (e.g. new sectors such as electronic banking and retail). The dominant characteristic of the region is a large concentration of small, medium and large companies operating in all segments of the electronics complex, and notably in the informatics sector with 51.9% of all national sales in 1987, 61% of national employment in 1988 and 51% (of 189 firms) of all registered firms in the sector (SEI: 1989:132). Competition is keen amongst S. Paulo based firms and together with a volatile national economic scenario for over six years, the companies have been forced to develop a strong market orientation at the expense of investments in R&D, indigenous development and quality control. Companies' efforts to control greater market share and guarantee return on investments have led many to turn to contraband and different forms of industrial espionage, as already discribed in Chapter Five, section 5.3.2.3.

During the period of field work and after it, larger corporations (and S. Paulo is headquarters for at least ten of them) were moving towards a greater concentration

of resources in selected industrial sectors Industrial restructuring aimed at improving firms' management capacity to effectively respond to changes in the economy, in technology and in the market while at the same time to consolidate the companies position in a sector with a very high growth prospect (Dados & Ideias, 1989:23). Moreover, S. Paulo's industrial and business tradition,including the experiences with science parks and industry-university collaboration programmes, served as a development model for similar initiatives elsewhere in the country.

7.2.2 The Rio de Janeiro Metropolitan Area

Rio de Janeiro never had a long tradition in manufacturing given its historical role as an administrative centre. The city became an attractive location for electronics firms after the opening of IBM's factory in Benfica in the mid 1960s and the creation of COBRA in 1974. It was also during the late 1950s and 1960s that other important industries were set up in the area including chemistry, metallurgy and transport (shipbuilding).

Electronics companies were concentrated in two parts of the Rio de Janeiro Metropolitan area: the Jacarepagua area in the south of the city and in Zona Norte, along the Avenida Brazil, located north of the city centre. Many of the largest national data processing centres were also located in Rio de Janeiro and the nearby town of Petropolis.

In 1988 electronics employment (excluding consumer electronics) in Rio amounted to 14.1% of total national employment. Industrial conglomerates including ABC, Cobra, Compart, Digiponto, Moddata and Racimec accounted for 6,000 jobs. The sector of greater importance in Rio de Janeiro was telecommunications (with 27.9% of all firms), followed by an even distribution of companies producing mainframes (16.7%), microcomputers (16.9%) and peripherals (17.8%).

Rio de Janeiro enjoyed, like S. Paulo, the proximity benefits of research centres and universities. These included PUC (Catholic University), UFRJ (Rio de Janeiro State University), Federal Fluminense University, the Army's Institute of Engineering and the National Technology Institute (INT) which was part of the extinct Ministry of Science and Technology. Many of these institutes had programmes in basic R&D and carried out selected joint research cooperation programmes such as the work done on supercomputing based on a parallel processor with 16 nodes (Info, 1988).

According to SEI's 1988 data on regional sales, Rio de Janeiro was the second market for informatics products in Brazil after S. Paulo with a diversified demand from most sectors of the economy. In 1988 sales in Rio de janeiro accounted for 17.2% of the total national sales in the year (SEI, 1988).

Companies located in the area profited from a range of incentives offered by both the municipal and state government and from three science parks located in the region. These included RIOTEC (Polo de Alta Tecnologia de Jacarepagua), BIO-RIO (Polo de Biotecnologia) in the Ilha do Fundao, and the Petropolis Science Park based in the city of Petropolis. Urban and property tax levies were the most common types of incentives offered by the state and city.

Of all national experiences with science parks the RIOTEC initiative was by far the most developed, as acknowledged by professional, academic and business circles. RIOTEC was set up in the southern part of the city in Jacarepagua region to serve the concentration of informatics firms in the area. The park in turn emerged partly as a result of growing pressure to bring together universities and industries in both basic and applied research, and with the support from firms who felt they could benefit from the park. RIOTEC was to receive financial patronage both from the private sector, which would oversee the park's management, and from the public sector which would fund some of the project proposals put forth by a consortia of member firms. RIOTEC plans were very ambitious including the construction of two sites with 43 and 54 companies each, covering a wide range of services (e.g. laboratories, training centres, commercial centres). The initiative was also based on the convergence of industrial infrastructure provision and regional development:

> "The park's third objective involved two aspects: one is to promote greater integration of the park with the S&T based centres in the region including the military institutes; the other aims to disseminate new technologies in order to modernize the public and private productive sectors in the state. The basic underlying idea for the two objectives rests on the fact that high technology is not an end but a means for social and regional development" (Riotec, 1987).

Between 1987-1988 there were 73 companies affiliated to the park, most of them operating in the informatics sector. However, very few of them had actually moved their facilities inside the park, and many of the park's development targets had not been achieved. To illustrate, of the proposed 43 companies (site I) and 54 companies (site II) that were to construct in the area, only 12 had begun building. The main reason given by firms was lack of money to fund their relocation. The park had also been the

victim of natural and social disasters. The January/February rains of 1988 destroyed large sections of Rio's shanty towns and urbanization in and around the city leaving many homeless. RIOTEC's industrial site which was partly urbanized, (electricity, drawn roads and sewage) practically vacant, unfenced and located in a flood-free terrain, was target of an invasion by homeless people. Short in cash and almost inoperative, the park had to borrow money from members to fence the property in less than four days to avoid invasion and future conflict with the community.

With respect to firm size, 30% of the firms located in the city had between 9 and 30 employees; 15% of them employed between 51 and 100 people, 20% had between 100 and 300 workers and the remaining had over 300 employees. Unlike S. Paulo, only two companies had more than 1000 work force. The degree of industrial diversification, production processes, management structures and inter-firm linkages were quite high in Rio de Janeiro, as confirmed by interviews and field visits.

Company **F**, established in 1966, started activities in the informatics sector in the early 1970s. The company produced banking and commercial automation equipment which, as discussed in Chapter four, was one of the most competitive markets in the country. **F** was also one of the few national companies to successfully export products (banking terminals) to Argentina, Colombia, Bolivia, and Portugal. Between 1987-88 **F** had five companies under its direct control employing a total of 187 people. Four of the subsidiary companies were located in Rio de Janeiro and one in S. Paulo. Restructuring plans for **F** led to the closure of the S. Paulo based subsidiary and a concentration of decision-making on one site. Employment also decreased significantly after 1985. The restructuring strategy adopted by the company included expansion of the plant's production capacity in high precision mechanics (essential for the production of printers and disk drivers), building of a new plant and a signing of a technology licence agreement with a Japanese company. It also included increased investment in human resources and a continued commitment to technology transfer and adaptation.

Another evidence of the national companies' commitment to streamline their operations to increase profitability was in human resource development and management-employee relations. Company **G** was created in 1974, the first Brazilian informatics company and destined to set the technological and markets standards for the rest of the national industry. Over the years **G** underwent many changes fulfilling its role of a national champion. A management team installed in 1985 focused on the role

of labour in the command and control of the labour process and sought to combine it with emerging production processes being tried elsewhere such as 'just-in-time' systems. For the company the workers were "the ones who know best how to optimize a production process, while the management's role is to transform workers' knowledge into operational routines." The 'just-in-time' system adopted for the PC line relied on the supply of all computer parts by 14 subcontractors who received the technical specifications and training from G (quality control). Provided the system worked well, the time between delivery of inputs and final products was not to exceed 48 hours. In practice, however, the system did not work well. G, like many other Brazilian companies, suffered from under capitalization, poor market performance and, in spite of its strategies to bring workers' participation into the production process, very high labour (and management) turn over.

To summarize, the heart of the national informatics industry is located between S. Paulo and Rio de Janeiro. The latter's main characteristic is a geographically concentrated industrial zone (north and south of the city centre) where firms have clustered and engaged in active and dynamic inter-firm transactions. The closeness to centres of excellence, the availability of a pool of skilled labour, the proximity to those individuals and institutions directly responsible for the formulation and implementation of the PNI, made Rio de Janeiro a desirable and profitable location. Many of Rio's strengths were, nevertheless, offset by an equal number of problems, including saturated communication transportation networks (long commuting hours), urban social stress (poverty and crime) and environmental problems (floods) which made day-to-day business very hard on many companies. Together with S. Paulo, these two regions were at the forefront of national economic life and concentrated all the best resources the country could offer to potential new national and international investors wishing to enter the informatics sector.

7.2.3. The South

The South (which includes the states of Rio Grande do Sul, Santa Catarina and Parana) presented an interesting contrast to the traditional industrial South-East region described above. The region has a tradition of family based manufacturing companies that were established during the 1930s. With the appearance of new information technologies, some of these companies diversified their production activities to

incorporate the new digital technologies notably in two sectors: industrial automation and instrumentation.

Most of the companies in the South originated there (87% of the sample), giving the region, and notably the state of Rio Grande do Sul, a high level of internal control and decision making. This had a direct impact on the ways these companies integrated themselves and the types of social innovations they were able to bring in.

Of the total surveyed companies located in the South, most of them produced industrial automation systems, computers and telecommunications equipment. 1988 employment was 5.7% of the nation's total as indicated in figure 6.4.

Different forms of municipal and regional schemes were set up to support the local industry. Five science parks were in operation, or were being planned, in the South. These included CITPAR in Curitiba, CERTI in Florianopolis, one in Joinville, and two other initiatives in Rio Grande do Sul.

According to survey replies Rio Grande do Sul was the most developed state of the region and offered the best infrastructure to accommodate new informatics companies coming into the area. In 1987 the state had 50 companies directly employing 48,000 people. This represented an increase of 300% from 1982 when there were 17 companies, 8 of which were producing peripherals and components. They varied in size having anywhere from 7 employees to 1,200. One company had more than 1000 employees, and the rest were distributed as follows (1988 data), 25% of all firms had more than 300 employees, 15% had more than one hundred employees, and the remaining 60% had less than 100 people. Larger companies like Edisa, Multidigit and Meno, on the other hand, contributed the most in terms of tax revenues to the state (Pereira, 1987:125)

Financial assistance in the form of development grants and management guidance were provided by the Rio Grande do Sul Development Bank. Technical assistance was provided by the local university UFRGS, which was one of the first institutions in the country to work with digital technologies and research. Four local companies were founded by university professors and therefore maintained the university-industry link that put them in business in the first place.

One criticism raised by companies operating in the area was an insufficient supply of skilled labour. Between 1987 and 1989 local universities trained 50 professionals per year in the fields of electronics and electrical engineering. This supply

was way below the 1987-1990 demand for 950 engineers and technicians to work in local industry (Pereira et all, 1987:146). This gap, together with the scarcity of financial resources, have delayed the region's industry growth and consolidation of science intensive industries in the area.

Different companies used different strategies to maximize their business opportunities drawing on the region's existing resources. Following a process affecting the informatics industry nationwide, in 1988 **H** restructured its activities to become more competitive. The company sold microcomputers under OEM contracts, supermicros produced in-house and superminis and mainframes using HP technology. Subsidiary **H1** produced work stations with HP technology. **H**'s restructuring strategy was to concentrate the activities of two subsidiaries (both located in the state) under the same management board and to adopt different strategies in different product markets. **H** did not include job cuts in its restructuring plans. In fact, from 1979, when it began operations, to 1988 employment increased 9 fold.

The predominance of higher level functions in Rio Grande do Sul differentiated the state from the other two in the region, Santa Catarina and Parana. Both, despite their 'developed' status as a part of the Southern region, did not have advantages in their favour such as renowned research centres, an industrial and business tradition, and a well developed services industry to attract concentration of high technology industries. Both states tried different development strategies using the concept of science parks. Two attempts in S.Catarina (Joinville and Florianopolis, the capital), were unsuccessful. They lacked proper management, resources and government subsidies. Parana based firms, benefitted from the proximity to S. Paulo and some medium sized companies considered the state as a potential location. Even so, Parana remained essentially dependent on the extensive agri-business operating in the state.

In sum, the Southern region occupied the third position in the nation with the highest concentration of informatics firms, jobs, and business after Rio de Janeiro and S. Paulo. Rio Grande do Sul offered the best business environment for companies willing to enter this sector including the availability of financial incentives offered by the local State Development Bank, and the proximity to the Federal University UFRGS. The industrial structure of informatics and other electronics firms in the South was characterized by a cluster of small family-based firms with a high degree of control of internal operations, capital and human resources to master more traditional (e.g.,

computer manufacturing) and innovative productive processes (e.g., new sectors such as digital instrumentation).

7.2.4. The North-East (NE)

The Brazilian North-East has for a long time been considered peripheral within the country. The focus of multiple and often inadequate regional development policies, the area has continually failed to successfully attract industry or other income-generation activities. In 1988 the North-East had the lowest position in the electronics industry in terms of both level and status of employment. The region hosted the lowest number of companies (1.5% of the country's total) operating in four areas: in groups 2 (micros), 3 (peripherals), 4 (parts) and 6 (telecom). Employment in electronics was less than 0.2% of the nation's total. None of these companies originated in the North-East region, making it the region where firms had the highest degree of external control over their management and production activities.

The activities carried out by North-East based companies were of low status within the corporate hierarchical divisions of labour including final assembly and packaging instead of being involved in the commercialization of products. Companies moved to the North-East for two reasons: to benefit from a regional incentive programme and, to a lesser extent, to exploit new markets (Fleury, 1987).

Sudene, the North-East regional development agency created in 1962, was the main driving force of regional development offering concessional loans and grants to willing investors regardless of employment effects, the nature of the productive activity, and, with respect to electronics, the technological content of products. Despite the apparent ease in obtaining Sudene grants, regional aid was not successful in attracting electronics companies to the region.

The second reason given by companies for moving to the North-East was to tap the unexplored local and regional markets. Two indicators highlight the potential size of such a market: sales and installations. In 1988, the North-East market was still very small, absorbing only 4.1% of total national sales (Table 6.2). In the six states that form the North-East region (Piaui, Ceara, Rio Grande do Norte, Paraiba, Pernambuco and Bahia), only 35 clients had computer installations (Table 6.1) including banks (a total of seven) civil construction companies (5), food processing companies (4), and commerce (5). These figures were not imposing enough to justify a relocation of

manufacturers and sellers into the area, even if we added the myriad of small business and individual users who were begining to introduce computers.

According to a company who sold products in the North-East, the 3000 kilometers separating the city of S.Paulo from Fortaleza and Recife (capital of Ceara and Pernambuco respectively) made manufacturing of products in the area economically unfeasible. Stocking was also ill-advised. Products were seldom displayed by the distributors or in showrooms. When a customer wanted to buy a system, an order was placed and the good was shipped from the headquarters to the consumer. This was corroborated at another interview carried out in the South-East by an informant who argued that "The ones (companies and individuals) who want computers have the money to fly to Rio and S.Paulo and buy them."(interviews).

Only some of the larger national producers had sales offices in the region's capitals including Salvador, Recife and Fortaleza. Other producers chose local distributors (representacoes) in the main capitals to represent their interests in the area. These companies occasionally trained sales personnel in the company's headquarters. In 1988 the North-East had 14.2% of the total number of distributors (1447) in Brazil. By way of comparison, the South-Eastern region had 44.8% and the North 5.2% (SEI,1989:24)

Another crucial issue affecting North-East based companies was the lack of centres of knowledge (universities, technical colleges) in the region. In 1988 only the universities in Pernambuco, Paraiba and Bahia offered graduate courses in informatics. The region also had a severe shortage of skilled workers.

Assessing the performance of companies in the area was a difficult task given the enormous gaps in the data available and the lack of data from direct field work in the region. This was partly compensated by telephone interviews and questionnaire responses. All six companies operating in the North-East were subsidiaries of companies located elsewhere. These firms had a precarious position vis-a-vis competitors in other parts of the country because of their level of under capitalization, low volume of production, restricted markets, and very important, a poor connection with the parent company's national division of labour.

Company **I1**, for example, was a subsidiary of **I** located in Rio de Janeiro, producer of super computers, disk drives, ATM's and other products. The company's main range of products and markets were in banking automation and, up to 1988, it

occupied a leading position in the top 15 companies in the sub-sector. Subsidiary **I1** was established during a period of high growth rates in the industry (1979-1986) to produce wires and cables and other parts. Two years later, in 1988, **I1** was operating in deficit and suffered from the economic and political pressures affecting Brazil.

J, a subsidiary of a Brazilian-based TNC on the other hand, produced integrated circuits. The plant's entire output was geared for export. **J** multiplier effect was very limited. The plant imported most its inputs from Japan and Europe. In 1987, **K** exported US$6.09 million or 40.6% of Brazilian exports in the sector (SEI,1989:79). These products were bought by the parent company following the branch plant/headquarters model practiced by TNCs in places like Mexico or South-East Asia.

During the late 1980s two science parks were established in the North-East, the NUTEC Fundacao Nucleo de Tecnologia Industrial, in Fortaleza and the PaqTe, Parque Tecnologico da Paraiba, in Campina Grande. These initiatives were part of another regional strategy to strengthen the weak articulation between firms in and outside the region. Both strategies were to be partly financed by the state and federal agencies (SUDENE, CNPq, and FINEP) to carry out their activities in the areas.

The presence of electrical and electronic companies in both parks were negligible (one company in Campina Grande had planned to produce digital equipment), despite the fact that one objective of both parks was to promote the electronics sector based on the economic success experienced up to 1986, and on the strategic value of new technologies.

To conclude, the experience of six companies based in the North-East during the late 1980s demonstrated that business opportunities for companies located in, or considering relocating to, the region were quite limited. The region's limited supply of skilled labour, restricted markets, distance from more dynamic production centres in the South-East and limited amounts of local investment capital, aggravated the region's overall peripheral position in the national division of labour. This added to a regional economy still primarily based on extractive activities (agriculture and cottage industries), Brazil's gloomy economic conjuncture rendered local initiatives (as in the science parks) weak in bringing a positive impact to the region's economy and to the national informatics industry at large.

7.2.5 Minas Geraes and Brasilia

This region groups together the state of Minas Geraes and the federal district of Brasilia. Minas is geographically and culturally nearer S.Paulo and Rio de Janeiro. Companies located there have long benefitted from proximity to other well developed regional economies around the Belo Horizonte and Sul de Minas regions.

In Minas Geraes informatics firms were concentrated in two areas. The most important cluster of firms both in employment and volume of business was the Belo Horizonte -Contagem region, a smaller cluster of firms found in the town of Santa Rita do Sapucai in the southern part of the state.

Belo Horizonte offered to companies similar business opportunities to those of S. Paulo and Rio de Janeiro, that is an industrial tradition and diversified regional economy, research centres and a skilled labour force, good transportation and communication facilities and some indigenous capital. A mixture of indigenous and out of state companies located in the area were engaged in the electronics sector.
The most prominent company was **M**, a member of a S.Paulo based industrial group with interests in all sectors of the electronic complex, and with plants and offices in most regions including Manaus. The plant produced ram's, discrete components, linear and digital integrated circuits which were sold primarily to the domestic market. **M**'s position in the national division of labour was solid. Protected by a special microelectronics policy, **M**, together with another Brazilian company, was selected to receive financial and technical support from the government to operate in the microelectronics market.

M enjoyed greater autonomy than an ordinary subsidiary taking decisions over investments and management/labour relations. This autonomy was positively translated to relations with employees and suppliers. Being in the microelectronic sector, **M** imported most of its raw material from Japan. This tight dependency on foreign suppliers inhibited a greater integration of the company in the local economy. This was further limited by a corporate decision to undertake most of the company's domestic sourcing in the S.P and Rio markets, partly due to the lack of suitable suppliers and by ignoring the potential of the B. Horizonte area.

Local S&T capacity was on the whole more limited in Belo Horizonte. The local branch of the federal university UFMG had courses focusing on informatics and the university engaged in a collaboration programme with IBM and other S. Paulo based

companies to re-design existing computer architectures based on analytical structures.

The other cluster of electronics companies was found in Sta. Rita 200 km from S. Paulo. Primarily an agricultural (dairy and coffee) region, Santa Rita nevertheless had four institutes and a faculty set up to produce electrical, electronic and mechanical engineers operating there since the mid-1960s. This cluster of institutes and entrepreneurial motivation of a selected few led to the creation of micro companies (two to 15 employees) operating in the telecommunications and electronics sectors. Some experiences were quite successful.

Company N originated inside a college laboratory in Sta. Rita, to produce antennas and television signal receivers to fit domestic TV sets. N found in the area the skills, suppliers and market to increase production four-fold during the first four years of activity. N developed its technology and products using traditional low skilled labour intensive methods. After 1984, the company had to change its business strategies to accommodate new policies (PNI).

First of all, N opted to invest in new R&D and to introduce digital technologies into its products. To do that it recruited two newly graduated engineers from the local technical school. At the same time, N decided to phase out its production of electric TV signal receivers. This was possible thanks to the mayor's decision to convert 'political favouritism' (paying votes back with jobs in the public sector), to some form of 'technological favouritism'. He also provided development grants to local infant firms for investment. N's owners eventually sold the traditional line of manufacturing to focus on more advanced digital TV signals, receivers and other communications devices.

Since 1987, N's business performance and that of other small companies located in the area deteriorated as a result of a continued national economic crisis. Sales plunged by 39% and an unplanned influx of new companies, attracted by the mayor's fiscal incentives, led to more intense competition. Firms also suffered from the region's lack of capital and bank credit lines.

The other extreme of the region was Brasilia. The federal district is a government town, par excellence, concentrating a large number of data processing centres and representative offices of leading national and international companies. Government procurement policies and the strategy to modernize and informatize the federal administration, attracted skilled personnel to Brasilia and even some companies

to cater for local demands. Brasilia remains, nevertheless, more a market than a production area for informatics goods. A total of 34 electronics companies are located in the region with the greatest predominance of industrial automation and telecommunications devices. Regional employment is 5.4% of the national total.

The clustering of firms in both Minas Geraes and Brasilia followed an industrial expansion trend that began in the late 1970s in synergy with the growth of the informatics industry.

For such a regulated industry, Brasilia's role was to be the political stage where pre-policy battles were fought and, after the policy was approved, where companies went to obtain approval for their industrial plans. Another isolated area was Santa Rita do Sapucai, where the concentration of small electric and electronic firms were product of the town's entrepreneurial and political flair rather than a direct result of national industrial policy.

7.2.6. The Manaus Area

The experience of Manaus is reviewed in the context of the Manaus Free Trade Zone. The data used in this section is secondary including technical papers and government data.

The key feature of the Manaus industrial hub revolved around the Manaus Free Trade Zone (ZFM) created in 1976 (Decree no. 288 of 2/67) to promote and finance economic development of the Brazilian Amazon region. The ZFM was part of a series of development measures implemented in the 1960s together with the local regional development agency SUDAM (Superintendencia de Desenvolvimento da Amazonia) and BASA (Banco da Amazonia). The main thrust of the policy was to foster territorial occupation of the Amazonian region through the promotion of economic activities in the area, and in so doing, to restructure the region's economy which until then was entirely based on extractive activities (e.g., rubber, timber, cocoa, fishing). The policy was based on an import substitution scheme (Suzigan, 1987) and targeted a gamut of sectors such as motorcycles, watches, optics, packaging and electronics.

Electronics were to receive the greatest attention from the state, particularly manufacturing activities in the consumer electronics sector. The mechanisms used to lure investors in the region included primarily tax levies on the import of components. This policy was particularly attractive to industries whose products required high levels

of input not yet available in the country or whose production was not economically feasible. According to Baptista, the combination of subsidies and a liberal import policy resulted in a 25-30% reduction in production costs in the Manaus area (Baptista, 1985).

The result was a gradual migration of selected industrial sectors from other parts of the country, and an inflow of direct forein investment mainly from Japanese companies (Yamaha, Honda, Seiko) seeking an opportunity to enlarge their regional markets. Television producers, for example, migrated to the North in response to changes in colour technology, to be able to import key components (Baptista, 1985). Most companies operating in the area depended heavily on the import of integrated circuits. Baptista calculated that 43% of all IC imports in the country were utilized by the consumer electronics companies (Baptista, 1985:88). All these industries had a common denominator: a dependency on key components that had to be imported, which represented a substantial share of production cost. By 1983, 39 firms operated in various sectors of the electronics complex and employed 37% of the region's work force (16,586). In 1988, there were 200 companies active in 20 different industrial sectors providing 40,000 jobs (Hewitt, 1988:60).

The creation of the ZFM, and the free importation of key components, had serious implications for the development of national technologies as outlined by the PNI. While it was not a part of the original development plan, the ZFM scheme encouraged producers to target their outputs almost exclusive to the domestic market. In 1987 94% of the local production was distributed to the rest of the country (Dytz, 1987).

Production activities carried out in Manaus were restricted mainly to assembly of final products using both imported and locally-sourced inputs. Some of these locally-made inputs were however, imported into the country and sold re-labeled 'made in Brazil' (circumventing the law of product nationalization) (Baptista, 1985; Hewitt, 1988).

Manaus suffered perhaps more than any other region in the country from the lack of qualified personnel to work in the area. National companies mediated the problem by maintaining their product development division in the headquarters in the South-East (Hewitt, 1988:75), or by recruiting in the South-East. During field work in 1987/88, out of an average of 20 job announcements in electronics advertised in the Sunday employment section of O Estado de S. Paulo, only one was for a position in

Manaus. This ratio was considered low both by the person in charge of job advertising in the paper, and by the recruitment officer of company **D**, a major S.Paulo based conglomerate with two plants in the Manaus area. The limited supply of jobs was linked to the 1987 Cruzado crisis. These positions were often offered together with a package of benefits (housing subsidy, company car, family health insurance, schooling) to attract the best candidates. Another strategy used by **D** was to fill positions with its own staff based in the South-East. Volunteers were offered advantageous benefits and a fixed term contract (5 years) with job security after termination of service in the Manaus area. This volunteer rotating system seemed to be the best way of keeping good professionals in the company, to circumvent the problems of recruiting an outsider who would also have to live in Manaus, and one that offered the least amount of staff resistance.

To summarize, the Manaus experience has had both positive and negative impact on the region's development and on the sustainability of the PNI. The consumer electronics sector which migrated and flourished in the region after the mid 1970s was as early as 1985, the largest in terms of output and the biggest consumer of electronics components in the country (Baptista, 1985). The resulting industrial agglomeration transformed the geography of Brazilian electronics and the urban geography of Manaus with the introduction of new factories, civil construction, services, public transport, retail, banking, and all sorts of other services needed for the reproduction of the industry and of the labour force moving into the region.

The ZFM strategy was also a threat to the PNI as the former liberated what the latter prohibited: the import of key electronics and electrical-mechanical components which were too costly, risky, or not yet economically feasible to be produced in Brazil.

The nature of the integration between a Brazilian based industry and global one was quite tenuous and characterized by a dependency on key legally imported or smuggled electronic components used in the assembly of final products in Manaus or shipped to the rest of the country where assembly activities were carried out.

Because of the heavy influx of imported goods into the area and a dependency on foreign suppliers, the local industry was subjected to sudden changes in the international markets. During the chip famine of 1987/88, Brazilian firms were well-supplied by the Japanese producers. So much so that American and European companies, starving for raw materials, decided to buy them in Brazil. When the

Japanese realized what was happening, they warned Brazil to raise its prices and/or control their exports. Company **D**, for example, had a remarkable performance. This was quite extraordinary when theoretically and even historically, Third World producers dependent on supplies from TNCs were the first ones to be affected by fluctuations in the international market, usually by having their contracts suspended (which did not occur in Brazil).

By 1988 when both government (federal and regional) and industry were fully aware of the limiting effects of the ZFM on the regional development of the Amazonian region, new programmes were proposed by SUFRAMA and FUCAPI. These included nationalization schemes, regionalization (intensification of local purchasing) and disaggregation (to prevent products from being imported and having their labels changed and being re-sold) (Hewitt, 1988:70).

Along similar lines to the Manaus import processing zone the government, in its most explicit regional policy, devised the export processing zones model in 1984, geared to the development of electronics and other industries in the country. This experience is reviewed below.

7.2.7 The Export Production Zones - EPZs

> "the EPZs would have a positive impact on the solution of the regional problem in the absorption of technology, job creation and the induction of industrial modernization. Its implementation will strengthen rather than a negatively affect the Brazilian industry"[1]

This section discusses one of Brazil's regional development policies, the export production zones, which was conceptualized as part of the national informatics policy. The first reference to the development role to be played by EPZs was made in the PNI. Article 24 of the law 7232 stated:

> "excepting the situations which may already exist and in the event that the corresponding technology is available in the country, the use of foreign technology by business which do not meet the requirements of article 12 shall be conditioned to: 1. production for foreign markets, 2.production units within the export production zones"[2]

The law also stipulated that these export production zones should be set up in the

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[1] ***Correio Brasiliense,*** 06/03/88:17 Conclusion of a report by Ambassador J.M. Villar de Queiroz on the impact of the EPZs in Brazil.

[2] Article 24, Law 7232 of 23/10/84.

Brazilian North and North-Eastern regions, and that the production and export of EPZs outputs were entitled to receive the same tax incentives created to promote companies located in other parts of the country.[1]

The provisions of these articles received very little attention from the industrial and regional lobby groups during the first three years of the law. By early 1987 the situation changed. Under the Ministry of Industry and Trade, the EPZ concept was re-launched with the goal of alleviating regional imbalances among some of the economically deprived zones and to transform them into internationally competitive industrial production sites. Or, as the Trade Minister then affirmed: "we'll be creating an industrial shopping centre to promote the industrial development of the North and North-Eastern regions".[2] "The EPZs represent "islands of freedom for the North and the North-East where current levels of economic development resemble those of Singapore, Taiwan and South Korea 15 to 20 years ago".[3] "The creation of the EPZ is also particularly opportune given the sharp fall of foreign and national direct investment in the country".[4]

Opposition to the EPZ's proposal was equally vocal. On one side, the Ministry of Science and Technology feared for the integrity of the informatics companies. The suspicion was based on the potential danger of government benefits to be pumped into the areas and how they could undermine the PNI achievements, as much as the ZFM. At the bargaining table, the Ministry of Science and Technology managed to guarantee that companies operating in the informatics sector could not be located in the EPZs. This exclusion could not, however, prevent the circulation of inputs and final products between the EPZs and areas where informatics firms were regulated (given the technological and industrial complementarity of the sectors) as occurred between firms located in the Manaus area. Even stronger opposition came from the House of Representatives against approval of the plan through decree and not through legislative powers. The group, headed by a SP representative Mr. J. Serra, produced a list of 300 signatures, including those of influential North-East politicians, against the measure and its importance to be decided by a single decree. Forces contrary to the creation of the

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[1] Articles 25, 26 and 28 of the Law 7232 of 23/10/84.

[2] ***Jornal do Brasil***, 18/01/1988:7 "Decreto de criacao das EPZs sera entregue hoje a Sarney."

[3] ***O Estado de S. Paulo***, 03/02/1988:18 "Ministro deve anunciar ZPEs oficialmente apos o carnaval."

[4] ***Correio Brasiliense***, 27/01/88:9 "MIC deseja ZPEs sem impostos."

EPZs failed. In reality, given the political scenario of the early 1980s, the EPZ plan was more a political issue than anything else. The plan was to serve as a bargaining tool in Congress to satisfy the North-East representatives who wanted a piece of the development cake for themselves and not a legitimate regional development policy as the law stated it.

The 1987 version of the EPZ was forged on the basis of a perceived successful experience in four South-East Asian countries (Taiwan, Singapore, S.Korea and Hong Kong) in overcoming economic underdevelopment. [1] According to the Ministry, the plan provided for the provision of infrastructure, fiscal incentives, free exchange mechanisms and repatriation of profits. It also recommended the utilization of a local labour force, complemented by the presence of foreign technicians and managers, and with specific legislation to protect the foreign investor against industrial actions in the EPZs areas.[2] The North-East region was chosen given its proximity to major North American and European consumer centres vis-a-vis the distant South-East Asian poles. In sum, the project was based on an assumed low transport cost comparative advantage rather than on cheap labour criteria.

The project also lacked a more orchestrated government support. During the formulation the government made no effort to publicize its intentions and to attract potential foreign investors to these industrial areas. It simply assumed that foreign capital would come, as they had been going to other Sout-East Asian localities.

From the TNC's side, the question was altogether different. The EPZ concept assumed that capital internationalization occured as a response to increasing labour costs and other costs in core regions, and that these increases could only be reduced by splitting the production process geographically between conceptualization, assembling and commercialization (with the first and last remaining in the core country, and the second relocated to zones where production costs were lower). In 1980 there were 166 EPZ spread in fifty five different developing countries. Despite such popularity, Chapters three and four above have argued against this interpretation of capital mobility based on Vernon's product life cycle theory and Frobel's NIDL theories. This opposition was also expressed by Cho who pointed out that at the same time (late 1970s) an increasing number of production facilities returned to the advanced capitalist

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[1] *Correio de Minas*, 21/02/1988:17 "Experiencia Asiatica desaconselha".

[2] *Correio Brasiliense*, 06/03/88:17 "Emissario do Planalto defende criacao das ZPEs"

countries (Cho, 1985:188). Between 1978 and 1980, the USA received 77% of the total value of global direct investment growth (Cho, 1985:189). The manufacturing sector, moreover, experienced the fastest rate of investment growth.

In 1989, the EPZ plan was revived again as a political issue supported by liberal factions in the government who saw in it a possibility to dismantle the long established tradition of nationalism and protectionism in the Brazilian economy. Considering the lack of support given to this regional development policy in 1984 and in 1987, it seems plausible to suggest that the Brazilian strategy to promote the EPZs is bound to fail the second time around. Firstly, the idea is isolated as a single piece of regional policy disconnected from existing regional policies to promote high technology industries. Secondly, as a product of ideological interests within the state, the EPZ concept takes for granted the strategic behaviour of TNCs regarding the location of part of their productive activities in other countries. Thirdly, given the current economic difficulties of the Brazilian government, the country lacks the necessary financial resources to fund the infrastructure projects needed to make these North and North-Eastern regions attractive to foreign investors (e.g. more roads, better communications facilities, etc.). Lastly, the Brazilian initiative comes nearly 15 years later than the rest of the world, ignoring significant changes in capitalist accumulation, analyzed above in Chapters two and three. The national initiative conflicts with current developments taking place in the AICs and if not properly supported will contribute minimally to the development of the national industry and its capacity to export.

7.3 Summary & Conclusions

The main purpose of this last empirical chapter has been to complement Chapter six's analysis of the geography of the Brazilian informatics industry by looking at the existence or non-existence of linkages between firms and localities, the types of regional policies used to promote the industry in different parts of the country and how these regional developments have affected and influenced the development of the industry nationwide.

The main findings of the chapter can be divided into three areas: the first looks at the composition and structure of industrial and service facilities of informatics companies nationwide; the second examines the relative importance of each region vis-a-vis other regions in the country and vis-a-vis international players, and lastly, it

assesses the relevance of competing regional development policies to concrete developments in the industry up to 1988.

Following a geographical and data distribution of firms used in Chapter six, this chapter demonstrates that there are considerable differences in the types of activities being carried out in the six regions. These differences can be described in terms of a hierarchy of functions (not necessarily complementary) being performed by different regions which gave them greater or lesser economic and strategic importance in the nation. S. Paulo and Rio de Janeiro were unquestionably the geographical, business, capital and R&D centres of the Brazilian informatics industry with the largest concentration of firms, jobs, services, centres of excellence and markets. The establishment and migration of informatics firms into both regions followed an earlier pattern of Brazilian industrialization, and was driven by a well developed spatial economy. The relative importance of other regional centres decreased as they moved away from the S. Paulo - Rio de Janeiro corridor, with extreme peripheral cases found in the North-East and Western part of the country.

Rio Grande do Sul came third in the list of potential sites being characterized by a cluster of small family-based businesses who entered the sector attracted by the business opportunities linked to new technologies. Firms located in the state were from the outset backed by state-led initiatives (science parks, subsidies and credit), the proximity of a good university and plenty of enterpreneurial initiative. The other two states were peripheral as far as their locational advantages were concerned.

Minas Geraes and Brasilia were clustered together for data analysis purposes but were regulated by different regimes. The region around Belo Horizonte and Contagem offered new investors and companies willing to locate there a well developed spatial economy without many of the urban and environmental pressures found in Rio de Janeiro and S. Paulo. Companies could also benefit from the growing regional economy. Brasilia has always been the political centre of the Brazilian informatics industry and policy, and a developed market (public sector) for informatics products. The political role of the city is likely to decrease after 1992 when the policy will be evaluated, but the city will continue to be a heavy consumer of information technologies.

Research demonstrated that the driving force behind developments in more remote clusters of firms such as the North-East, Santa Catarina and Minas Geraes were

a result of specific regional development policies, or local entrepreneurial drive that brought together basic ingredients to attract new industries and jobs, namely the ZFM in Manaus, science parks and Santa Rita do Sapucai.

On the whole, regional development policies including ZFM, the science parks and the EPZs were ambitious blue prints for regional development, each having had a different spatial and economic impact on regions. The first one certainly altered the geography of the consumer electronics sector forcing plant closures and or relocation from the South-East to the North of the country. It facilitated the internationalization of the sector and the free-flow of legal and illegal imports into the country. These imports became vital inputs for the manufacture of 'Brazilian-made' products for sale primarily to the domestic market. To conclude, the chapter makes a contribution to the debate on uneven development by illustrating how a national industry has been created and settled in a country.

CHAPTER VIII
VIII CONCLUSION

8.1 Introduction

This chapter draws together the major findings of the research and is divided into five sections. First, it reiterates the argument and objectives of the thesis as presented in the introduction (Section 8.2). Section 8.3 is a summary of the contextual information gathered and presented in Chapters two and three. Section 8.4 summarizes the empirical findings presented in Chapters four to seven. Finally, Section 8.5 gives a final assessment and discusses achievements and limitations of this research.

8.2 The Thesis Objectives

In this thesis I examined both past and present links between the creation of a national informatics industry in Brazil and those of a global electronics complex. I argue that policies adopted by the Brazilian government (summarized in the Informatics Law of 1984) were instrumental in the development of the present industry. However, these policies have not considered the links between the development of the Brazilian industry and the development of informatics industry worldwide, and therefore failed to acknowledge the influence of international events (e.g., technology and market changes) on Brazilian initiatives.

The focus of this thesis has been Brazil's informatics sub-sector, which has been at the centre of growth. "Informatics" was defined as a particularly pervasive industry drawing from several industrial sectors and involving different technological levels and complexities. The definition of the informatics sub-sector in Brazil given in the Introduction followed the guidelines outlined in the 1984 Informatics Law and included producers of computers, peripherals and parts. This thesis also compared and contrasted the policies and performance of the informatics sector to other sub-sectors of the electronics complex. This aimed to situate informatics in a broader industrial and technologically relevant context. Technological developments in the industry have led to dramatic changes in the competitive structure of this sector and have transformed the way people and communities perceive the strategic value of informatics.

The approach adopted in the thesis was first, to review and describe the technological context that marked the development of electronics and informatics

worldwide. This was done in the Introduction. Secondly, the thesis examined the international context of global informatics focusing on experiences in the AICs and NICs. "The international situation [which has been described in Chapters two and three] is not simply a back cloth to events played out on the national and regional stage; the two levels stand in a dialectical relationship of whole to part in which the parts (countries, regions, and individual firms and plants) actively constitute, reproduce and transform the whole while simultaneously being influenced by their places within the whole." (Morgan & Sayer, 1988:119). Following Morgan and Sayer, the third step was to move from a global to a national level to examine developments in Brazil.

The Brazilian experience was the focus of four chapters (four to seven). The main purpose of these chapters was to review the policy (Chapter four) and the industrial performance of the sub-sector (Chapter five); to map out the geography of the industry (Chapter six) and to analyze the interactions between firms and places (Chapter seven). The regional focus, central to this thesis, aimed at 1) putting Brazilian development in a sharper perspective, and 2) contributing to the existing literature on the theme by offering an innovative and critical way of analyzing industrial growth. As indicated in the Introduction, the literature on Brazil's experience in developing a national informatics industry concentrated attention on political, economic and technological facets of the industry and policy. While opinions expressed on the Brazilian initiative were mixed, in general most analysts have supported or have at least recognized the benefits of Brazil's protectionist strategy as a prerequisite for the development of infant industries. Moreover, industry (including both academic, government and business) analysts have taken regional development processes for granted paying very little attention to how different policies, technology changes and government strategies influenced developments in Brazil.

The thesis has drawn heavily on secondary sources looking at the Brazilian experience per se and on the experience of other developing and developed countries. Primary sources of data have been used to cover gaps in the existing literature, and to analyze changes in the geography of Brazil's informatics industry. Primary research has focused on industrial collaboration between AICs [illegible] the lack of effective forms of collaboration between industries, and the emergence of science parks in developing countries. With respect to events in Brazil, primary research focused on the perception of firms vis-a-vis the government policy and their business interests. It also focused on

successes in electronic banking, the role of contraband and its effect on the competitiveness of firms, on the support given to science and technology, and lastly, on how firms organized themselves and benefitted from their particular locations.

The theoretical framework used in the thesis was based on a review and synthesis of three major theoretical contributions on development. These included the arguments put forth by dependency theory, the NIDL thesis and by regulation theory.

The first theory, dependency, is limiting in its interpretation of the real possibilities of growth and development in the Third World. Based on a system of unequal exchange between developed and less developed parts of the world, dependency theorists do not see the possibility of full development in the Third World. Furthermore, events described in the thesis regarding the creation and growth of new industrial sectors in many parts of the developing world have challenged the dependency paradigm.

The second theory, based on the New International Division of Labour Thesis, explained Third World industrialization as a result of the expansion and relocation of TNCs to areas over and beyond their national boundaries. According to the NIDL, the internationalization of capital that started in the early 1950s was driven by TNCs and responded to TNCs' interests. The assumption that foreign capital operated in a free-wheeling manner around the globe searching for what Smith called 'profitable, individual and particular' capitals concealed the important role played by the state as an active development agent (Smith, 1984). The role of the Brazilian state in developing a national industry rebuts the NIDL thesis (explained in Chapter four), rendering the NIDL thesis an inappropriate analytical framework. It has been shown however, that the NIDL was useful in explaining developments in other parts of the developing world (e.g., Second-tier Latin America and Asian NICs).

One important theme raised in the thesis is uneven development. Smith described unevenness in terms of a model of capital movement between sectors and sub-sectors of the economy that responded to declining rates of profit. Both model and analysis were dissociated from what Smith described as "messy historical conditions permeating real events." (Smith. 1984). The subject matter addressed in this research is laden with messy historical, political and technological conditions.

It was therefore the complexity of developments of informatics industries in both AICs and NICs that made the framework proposed by regulation theory appropriate to

understand developments in Brazil. Regulation theory defines the global economic trends that prevailed from the late 1950s to the mid 1980s as Fordism. This regime has been ridden by crises and booms influencing the world at large.

The following section summarizes the main findings of Chapters two and three which described the international context.

8.3 The International Background

The international context was dealt with in Chapters two and three. The purpose of both chapters was threefold. First, following regulation theory's conceptualization of Fordism, to look at the changing nature of capitalist development during the 40 odd years of the informatics industry. In this respect, the chapter's contribution was to conceptualize and explain capitalist internationalization of the industry in terms of competing industrial development regimes (American, Japanese and European). Secondly, the chapter aimed to demonstrate the role of states behind the development of major multinational corporations and national industries. This was particularly evident in the review of Japanese and European policies with respect to electronics. Lastly, the chapter focused on some outcomes of these industrial development strategies namely with respect to labour, technology and regional development policies.

To summarize, it has been shown that the American model predominated from the 1950s, when the United States produced its first computer, to the present.
The American model was characterized by:

- A policy regime based on a direct support to ('hands on') defence related activities, contrasted by a 'hands off' *laissez faire* approach to activities in the civil sphere, these in the hands of American TNCs.

- An industrial structure based on the existence of very large, vertically integrated companies whose internationalization strategies began in the early 1930s and who have had a commitment to developing state-of-the-art technologies and to being at the fore front of the market.

- Production systems differentiated by sectors, but based nevertheless on large scale, geographically distributed facilities polarized between different regions and different productive activities (front-end versus back-end activities).

This model afforded American based corporations the opportunity to develop and to maximize their business opportunities over and beyond national boundaries for nearly

35 years (1950s to 1980s). After the mid 1980s the model is being eroded away by cut-throat competition from Japanese competitors operating initially in selected sectors (consumer electronics, semiconductors) and gradually moving to other segments of the electronics complex. Thus, it has been argued, the increasing pressures from Japan have already turned the attention of some major European and American corporations to a close examination of the Japanese strategy.

Set in a sharp contrast to the American approach, the Japanese model was characterized by:

- Policy institutionally centralized under a single agency (MITI) whose enforcement powers have gone beyond the life of different governments, assuring continuity and wholeness to the development of a gamut of industrial sectors of the electronics complex;

- Emphasis on the importance of competitiveness in internal markets, making Japanese companies very fit to face export markets. First, the strategy was based on internal market protection and reduced export activity. At a second stage, it was characterized by liberalization of domestic markets and exportation of productive facilities to circumvent protective barriers, as, for example, in the EEC case, in Brazil, and other countries.

- Emphasis on applied and basic R&D, so as to keep Japanese corporations, notably semiconductor producers, in the fore of the technological race. Conscious of the strategic importance of micro components and miniaturization of products, Japanese corporations have managed to introduce product innovations ahead of American and European contenders.

-Process technologies favouring the adoption of economies of scope, flexibility and 'just-in-time' systems, rendering factories able to adjust rapidly to technological and market changes occurring worldwide.

Set between an American and a Japanese race is the European experience. Europe's approach to protecting and securing what was left of the European informatics and electronics industry from the predatory activities of both Japanese and American TNCs in the European markets rested on the member countries' perceptions of Europe's strategic, economic and political importance as a regional power. The discussion of this approach suggested that Europe operates like a unity of diversities, that is a collection of competing national interests having to compromise to get the best share of the pie.

Concentrated in the hands of many projects, European nations and firms are more firmly involved in the definition of European wide communications standards than in competition to be at the fore of technological developments or to overtake leaders like IBM or the Japanese runners-up.

To conclude, the main findings of Chapter two were that developments in the AICs were far from being homogeneous and/or fully orchestrated. Instead, cut-throat competition and higher barriers of entry resulting from escalating R&D costs have shaped the industry worldwide. Leading AICs partners such as the United Kingdom and France, have not been able to match American businesses and Japanese government's support to this sector and have fallen behind the race. The consequences of competing AICs development regimes on other potential entrants in this industry, namely developing countries like Brazil and other NICs have changed over time and amounted to contrasting outcomes. These were explored in Chapter three.

The aim of Chapter three was to situate the experience of many NICs in developing national informatics industries in the context of the industrial development regimes described in Chapter two. The chapter also compared and contrasted the experience of NICs and AICs. It was shown that development and industrialization patterns differed significantly for both groups. AICs economies have had a longer history of industrial development with internationally strong and competitive capital goods industries which benefitted the development of electronics and informatics industries. The NICs, in turn, share common characteristics of latecomer industrialization including very fast development histories of less than 40 years. In the quest to develop national industrial sectors, NICs have suffered from small or ineffective/disorganized capital goods industries which are important suppliers and consumer of informatics, and from a poorly developed or absent array of industrial and social linkages (e.g., support services, subcontracting relations, skilled labour, support to S&T programmes).

In spite of the differences between NICs and AICs, Chapter three has shown that many NICs have managed to develop national informatics industries. These developments described in terms of a growing intra-regional differentiation among developing countries challenges the theoretical rationale advocated by dependency and NIDL theorists. Guided by different principles, both theories advocated a situation of variable dependency between AICs and NICs. Reiterating from Chapter one, for the first group, dependency theorists, development takes place in more advanced countries

at the experience of the perpetuation of underdevelopment elsewhere. For the NIDL theories the industrialization that started in the 1960s and 1970s resulted from capital accumulation forces headed by American corporations who sought new market opportunities. Both theories however, failed to account for the role of the state in shaping the development process, and the role of national capital and its vested interests in the industrialization of their specific countries. Therefore, while new Third World markets were an important factor in the consolidation of American development strategies, some NICs, notably the first-tier Asian NICs succeeded in differentiating themselves from other NICs and even AICs.

The conditions under which this process of differentiation occurred were complex and particular to both Asian and Latin American NICs. With respect to the first group of NICs it has been suggested that intra-regional differentiation (leading to a split between first- and second-tier NICs) was possible due to four factors. One, the utilization of export orientation as a mechanism to acquire scale economies, and command of process technologies and labour skills enabled the first-tier Asian NICs to become internationally competitive. Two, pre-export promotion strategies (based on import substitution and market protection in the 1950s and early 1960s), have helped and eventually consolidated the position of local capital in these national industries. Three, national firms (e.g., Samsung, Leading Edge), have managed to gain a position in the industry's international division of labour (as major world suppliers of computer systems) and can better defend their (and national) interests. Four, since the mid 1980s, the proximity to Japan, and the flow of Japanese products, technologies and production processes through Japanese FDI and Japanese foreign aid, has passed on to these NICs the ideology and principle of the Japanese industrial development regime described in Chapter two and summarized above.

The principles guiding the development of informatics industries in Latin America have been somewhat different from those outlined above. American TNCs control most of Latin America's regional markets, the technological trajectories employed by national Latin American firms, and the industrial and managerial models developed throughout Latin America. In an attempt to slow the speed of internationalization of electronics industries throughout Latin America policies formulated by various countries in the region have hoped to halt the expansion of the American model and corporations in national territories with a view to strengthening

national industries and markets. Brazil, Mexico and Argentina were in a better position to design and implement targeted policies relying on the existence of a broad industrial base, human resources, capital, market and state support.

To conclude, the effect of AICs led industrial development regimes for both Latin America and South-East Asia have been expressed by a) differing roles of international capital and types of FDI in both cases; b) a labour force differentiated in terms of skill, wages, and their condition of internalizing the social benefits of electronics technologies in their national social strata, and lastly c) a geographical level of differentiation with pockets of growth, stagnation, and underdevelopment, against the background of a mushrooming of science parks, export processing zones, and other forms of regional industrial development strategies to host electronics industries: in sum, a very complex and uneven development process.

The international setting discussed by both chapters provided the context for an analysis and discussion of the Brazilian experience. The factors considered to analyze the Brazilian experience were historical development of Brazilian industrialization, the national informatics policy, policies regulating other sectors of the electronics complex and support for Science and Technology in the country. These were addressed at length in Chapter four. Drawing from the available literature I also focused on aggregate industrial performance looking at computer installations, sales and employment.

8.4 The National Framework

This section summarizes the main findings of Chapters four to seven.

The overall aim of the four chapters on Brazil was to analyze the Brazilian experience in a global context to identify the existence or non existence of linkages between the Brazilian experience and that of the international informatics industry and the implications of these for a sustained success of the Brazilian initiative.

Brazilian industrialization was the result of the alternation of import substitution and export promotion strategies, and the alternation of civil and military rulership whose liberal ideologies endorsed a top to bottom development approach.

The level of Brazilian industrial output has been significantly high for a long period of time. Two factors contributed to that. First, the national economy has favoured primarily the internal market. However, after nearly forty years of import substitution the Brazilian industrial base is in urgent need of restructuring,

modernization and expansion. The export sectors which lead the performance of the Brazilian economy internationally (and therefore which comprise the 'modern sector' of Brazilian industry) are subsidized (at a high public cost) to make Brazilian products price competitive. The second factor contributing to high levels of growth was a state-led capitalist growth based on the extraction of *absolute* surplus value through the exploitation of a national and poorly paid wage labour. The benefits of this buildup have been appropriated by a class of national capitalists and state bureaucrats; than by any process of creation of value based on the support, and encouragement of other factors such as science and technology, education, productivity gains, and provision of basic conditions for the proper reproduction of the labour class. The result is an uneven concentration and distribution of wealth leading to social inequalities and rising social pressures pointing to the exhaustion of this growth model. It is in this context that Brazilian informatics and the model used to promote its development emerged.

The Brazilian model, it has been argued here, personified the ideology and values that propelled the industrialization models used in Brazil. It has been inspired by the American industrial development regime and has drawn from other regimes selected notions such as picking national champions, and policy centralization (from France). The model, however, fails in achieving its desired goal (to build national S&T capacity and an internationally competitive national informatics industry).

Reiterating from Chapter four, the model was based on prerequisites and assumptions. With respect to the first, the model necessitated TNCs willing to provide state-of-the-art technologies to Brazilian firms with little or no control over their use. It also assumed the existence of a national absorptive capacity which could transform, adapt and develop new technologies suitable for the Brazilian market. With respect to the second point, the model ignored patterns of capital internationalization practiced by TNCs including export (licencing) of outdated technologies and/or the relocation of vertically disintegrated assembly plants which hampered the internalization of knowledge of processes and organization which are essential components of any embodied technology. Second, it neglected the changing and converging nature of digital technologies by isolating the computer manufacturing sector under a market protection, and ignored existing policies for consumer electronics and other sectors of the electronics complex. Third, the model anticipated the existence of a solid national S&T base, or in its absence, a strong and consistent support for S&T programmes from government and

private sectors. Lastly, it predicted that once firms received and adapted foreign technologies they would achieve productivity gains and become internationally competitive.

The changing nature of digital technologies have led to a convergence of industrial sectors. In the AICs context this opportunity was seized by Japan and later by the EEC as a strategic move to maximize the position of Japanese and European companies in the international informatics industry. The thesis has shown that in Brazil political divergence between national interests groups over the formulation of the national informatics policy resulted in a collection of diverging national sectoral policies for informatics, telecommunications, consumer electronics, microelectronics and software, and in different relationships with foreign capital operating in each of these sectors.

This diverging policy structure affected developments in Brazil in at least three ways. It made it more difficult for companies operating in various sectors of the electronics complex to benefit from technical developments taking place in other sectors. It enhanced the rigidities and differences between Brazilian and foreign capitals across the whole electronics complex. Lastly, it diminished a national capacity to maximize limited financial and technological resources to achieve desired outputs: that is a strengthened national technological capacity to serve national interests in many industrial sectors. This finding is corroborated by a review of conflicting regional development policies (Chapter seven) that enhanced unevenness between the consumer electronics industry in the North (the Manaus export processing zone) and other industrial sectors clustered in other parts of the country.

National support for S&T programmes was the last factor addressed in Chapter four. Restating from Chapter two support for S&T programmes was one precondition for the successful development of technology intensive industries in the AICs. NICs approach to supporting national S&T programmes varied. In general first-tier NICs in both Latin America and Asia have invested in developing human and technical resources. Compared to other countries Brazil's commitment to S&T has been relatively consistent. Chapter four, however, examined this commitment to detect that the national S&T system is very fragile. This fragility results both from an uneven financial support to S&T programmes over a period of nearly 20 years (1970-1989), and from a gradual process of technological obsolescense of research equipment

resulting from import restrictions imposed pre-1984 and post 1984. Permeating these two aspects, a succession of economic crises have eroded the isolated success achieved by the national S&T policy (e.g., salaries of researchers, value of scholarship programmes).

Chapter five focused on the industry's performance. Over a period of 15 years from 1974 (creation of Cobra) to 1989 (end of research), for five years the industry was regulated by the PNI, the performance of the Brazilian industry surpassed that of Brazilian based TNCs, reached a plateau, and experienced decline primarily because of crises in the national economy.

Some achievements of this period amount to a significant involvement of national capitalists in the sector, represented by the number of firms that have been created since 1974; the creation of 30,000 plus direct jobs in informatics and another 95,000 jobs in other sectors of the electronics complex including informatics services. The literature reviewing the performance of the industry argued that the market reserve (and PNI) heightened national industrialists' commitment to developing and adapting new product and process technologies, and to investing in R&D and human resources (Piragibe, 1985; Tigre, 1983, 1987). With respect to human resource development, it has been demonstrated that the PNI contributed to the creation of a new model of employment where the kinds of jobs created and offered included a proportion of skilled engineering and technical labour (Hewitt, 1988).

To contrast these achievements, many industry analysts have demonstrated the limited international competitiveness of Brazilian firms. This has been illustrated with price comparisons with similar goods produced abroad, export capacity and production scales, all of which, despite low national labour costs and a commitment to the principles of technological autonomy put forth in the policy, have not managed to get Brazilian firms out of their sheltered domestic market (Cline, 1987; Firschtak, 1986; Piragibe, 1984; Tigre & Perine, 1984). Perhaps more telling of the performance of Brazilian firms than interpretations given by the literature was contraband. It has been shown in the thesis that contraband has become an important mechanism used by firms and consumers to bypass national policies and to achieve desired and expected profit targets. Smuggling and contraband, and the long term implications of these practices for the success of the Brazilian initiative, have not been fully addressed by the literature, nor by the government. Both have limited their interpretations to a political

and an economic view of events which led to optimistic conclusions about the Brazilian experience.

The limitations of the literature also extended to other dimensions, namely the spatial context of developments in Brazil, and the political and economic context of conflicting regional development policies. These dimensions were addressed in Chapters six and seven.

The two chapters looked at the industry in terms of national geographical distribution and growth. Also examined were the linkages between firms and localities, the types of policy used to promote the informatics sector in different parts of the country and how these have been shaped and affected by local conditions. The main contributions of the two chapters were to collect and analyze existing geographically specific data and present it in a format relevant to the thesis discussion. Another innovation was the analysis of different regional development policies with respect to their support (or lack of) of the guidelines outlined in the PNI.

The geographical analysis of the growth of Brazilian informatics exposed a gloomier picture than that portrayed by aggregate indicators such as sales, outputs, firms registration and employment. The character of such complex industrial development was also difficult to measure. One reason for that was the permanent state of flux of the development of the informatics industry on the one hand and changing regional conditions on the other.

The main findings of Chapter seven covered three areas. First it presented the configuration of industrial facilities in different areas. Secondly, it assessed the relative importance of each region vis-a-vis other regions in the country and international players. Lastly, it evaluated the relevance of competing regional development policies for informatics.

The four maps presented in Chapter six summarized the patterns of industrial growth of the electronics complex in Brazil from 1974 to 1988. Chapter six summarized the industrial sectoral composition in the six regions. The spatial division of labour of Brazilian electronics in 1988 included a high concentration of firms operating in all sectors of the complex in three regions (S. Paulo, Rio de Janeiro, and the South). The North had a high concentration of consumer electronics firms. The Minas Geraes and the North-East were sites for producers of parts. Brasilia was a major political centre and consumer market. These divisions of labour reflected an hierarchy of functions (not

necessarily complementary) performed by each region according to their strategic position in the nation. Not surprisingly then, the core of the Brazilian informatics industry was in the S. Paulo-Rio de Janeiro corridor with the largest concentration firms, R&D centres, services, markets, subcontracting relations between firms, local capital involvement and a strong foreign presence. The relative importance of other centres decreased as they moved away from S. Paulo with extreme peripheral cases in the North-East and Western parts of the country.

It has been demonstrated that the constraints on successful development of electronics industries in the North-East region were not restricted by the inability of the region to attract potential investments nor to develop a class of researchers and research activity in the local universities, but by the peripheral position of the North-East vis-a-vis other regions in the country. This peripheral role results from regional development strategies designed to satisfy regional political interests in congress (e.g., the EPZs) rather than the region's needs and potential.

In direct contrast with the North-East, firms located in the South had greater opportunities to withstand the impact of policy liberalization drawing on their well developed linkages (industrial, commercial, financial and political) inside and outside the region. Moreover, the involvement of local capital in the industrial development of the region provided an additional and important internal control factor which was absent from investments made in the North-East, and to some extent in the North.

The last major contribution of the thesis was an analysis of regional development policies that came in parallel and/or separated from the PNI. These included the Manaus Export Zone, the science parks, and the Export Processing Zones initiative. The first policy was formulated before and independently from the PNI and aimed at bringing about the development of the northern most Brazilian region. The impact of this policy was reviewed at length in Chapters four and seven.

The science park approach, on the other hand, was linked to a wider and global approach to regional development, and it was geared to performing a catalytic role bringing together public support and private resources and interests to benefit clusters of companies in a given region. It was meant to be a positive departure from a previous version of regional development targeted at technology-intensive industries based on export promotion zones. Brazilian experiences in developing science parks however, could not withstand the vagaries of the national economy. Most attempts failed not due

to lack of motivation but to the lack of public and private funds.

The last type of regional policy resulting from the national initiatives to promote informatics was the EPZ initiative. Destined to fail even before they became law the EPZs were a political token to satisfy the nationalistic anger of the North-East over its underprivileged economic position vis-a-vis other parts of the country. The main problems behind the concept were: it ignored the real nature of production activities (e.g., labour intensive assembly of low value added products) carried out inside existing EPZs located in other parts of the world (discussed in Chapter three). It neglected the patterns of capital internationalization behind the development of EPZs in South-East Asia which were associated with the export of assembly operations and theorized by the NIDL. Lastly, like with the PNI, the EPZs concept assumed that foreign capital would be willing to invest in Brazil.

8.5 Final Assessment

The analysis carried out in this thesis about the experience of Brazil in developing a national informatics industry demonstrates that Brazil in its approach to tackling a complex issue of technology transfer, building of national capacity, creating a nationally and internationally competitive industry, has been victim of excessive nationalism. Moreover the approach was shortsighted.

Nationalism was a common thread used to sew together political, technological and economic factors. However, this nationalist net was not cast wide enough to include other interest groups inside Brazil nor was it strong enough to resist pressures from foreign and national capitals. The nationalist group included politicians, the military, scientists, engineers and academics, and government users who shared common interests regarding computer technologies.

The second group included the international players (TNCs) who had control over key product and process technologies, and had their own views of how they wanted to handle their business in the country. Technological change and convergence was also an important factor. The appearance of the microcomputer lowered entry barriers to many developing countries. Ten years later cut-throat competition between AICs players inspired by capitalist fears of declining rates of profit (e.g., European based companies) led to greater investments in R&D and greater mobilization of political, technological and economic resources which pushed barriers up again.

The last important factor was a missing link between Brazil's national development plan and the country's national S&T policies. The PNI has been an important chapter in Brazil's S&T policy, however, it was formulated at the margin of what should have been an all-encompassing national economic development policy. Instead, the Brazilian strategy for informatics was segregated from other important national policies (e.g., S&T, education, regional development, export promotion, industrial modernization), and as such it could not benefit from nor contribute to these policies.

As of 1989 when the research for this thesis ended, and certainly thereafter, the initial impetus behind the policy had already lost its speed. The PNI was under a lot of pressure from competing fronts.

Brazilian based TNCs wanted the market protection removed because it clearly put limits on these companies' growth. Given the strategic role played by TNCs as suppliers of technology, their pressure counted. The PNI also discouraged many other TNCs (operating both in the electronics and other industrial sectors) from wanting to invest in Brazil.

Pressures came from other sectors of the economy which needed to restructure and modernize themselves and therefore depended on new technologies which Brazilian informatics producers could not deliver, and more importantly could not produce.

Ultimately, there were social and economic pressures pushing rates of growth downwards following the Cruzado and the Collor plans. These periods of severe profit squeeze forced industrialists to seek new strategies including export markets and contraband. The thesis has shown, however that the performance of Brazilian firms in the former were limited. The latter in turn, was an attractive and effortless way for companies to remain in business. Its implications cannot be predicted.

This thesis has contributed to the debate on industrialization in developing countries by looking at the Brazilian experience. It provided an understanding of the Brazilian experience looking outward, that is, the position of Brazil in the world system. The analysis revealed, as already stated, a very uneven configuration over the national territory which in turn suggests a more profound unevenness of Brazilian development at large. Thus, the possibility of continued development of the Brazilian industry is very much tied to the development of the country's social structures at large,

which as I have said, require further investigation.

This last point brings me to discuss the major shortcoming of this type of study. It is both a theoretical and historical/empirical reconstruction of industrialization over different localities, whose major theoretical framework, as earlier stated, is based on the changing nature of historical regularities between different regions. It is not therefore oriented toward policy recommendations nor it does offer clear-cut yes/no conclusions. It is instead a contribution to a debate that has been very important for Brazil and other NICs centered around sustainable development, technology transfer and building of national capacities. This debate has received considerable attention from government, industry and academics, but notably in the case of Brazil, it has focused too much on outcomes rather than on processes and on policy rather than politics.

Appendix 1 Research Methodology

Introduction

This appendix explains the methodology and describes the research design used in this thesis. The aim of the thesis was to examine the linkages between Brazil's informatics industry and the global industry. With particular respect to the Brazilian case, the objectives of the empirical work were fourfold: to examine the Brazilian policy and how it facilitated/hampered the relationship between Brazilian and foreign companies (Chapter four); to examine the performance of the industry by looking at the level and nature of competitiveness (Chapter three); to map the geography of Brazilian informatics (Chapter six), and to examine the linkages (or lack of) between firms and localities (Chapter seven). Both primary and secondary sources were used to develop the arguments of this thesis. These are explained below.

Sources of Information

This section details the primary and secondary sources of information used in this thesis and explains the research procedures used for different sources and how and where this information was used.

The primary sources used in this thesis included two surveys carried out in 1987 before going to the field, followed by a questionnaire/interview with individuals working in government, professional institutions, research institutions, and others carried out in 1988/1989. Secondary sources include data available from the Ministry of Science and Technology, from commercially established industrial databases, academic and technical papers, newspapers and journals.

Primary Sources

Primary sources were used in this thesis to obtain information on broad aspects of the informatics industry and policy in the AICs and NICs, and to obtain information on key issues affecting the development of the Brazilian informatics industry. In what follows I describe the main sources and purposes of information collected.

From November 1986 to November 1987 I contacted relevant institutions, companies, and government bodies to learn about the electronics industry, industrial policy, regional development policies and their implementation. I visited and interviewed professionals working in these institutions and those whom I could not personally visit were contacted by letter. These included:

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Government Institutions

DTI - Dept. Trade and Industry, UK
Alvey Directory, UK
ESPRIT Directory, UK

EEC Institutions

EEC - ESPRIT Directory, Brussels
IBI - International Bureau of Informatics, Roma

These institutes/departments were contacted to obtain information on EEC policies in science and technology.

Research Institutes

SPRU, University of Sussex,
CURBS, University of Newcastle.

These two institutes have been directly involved in the evaluation of the ALVEY and ESPRIT programmes on behalf of the British Government and of the EEC.

Companies

IBM, UK
UNISYS, UK
Ferranti
ICL
Siemens

These companies were approached to provide annual reports and other documentation available about their international operations. I visited and interviewed heads of international operations department of three of these firms.

Parallel to these interviews I did a survey on different government policies for informatics throughout Latin America. Fifteen government agencies received the questionnaire, four replied to the questionnaires and two sent their own information.

Autoridad Informatica Del Gobierno, Chile
Centro Nacional de Computacion - CENACO, Bolivia
Departamento Administrativo Nacional de Estadistica, Colombia
Subsecretaria de Informatics Y Desarrollo - SID, Argentina

The Officina Regional de Ciencia y Technologia de la Unesco, Uruguay also replied to the letter survey. The purpose of this survey was to identify any other relevant information about national policies, to identify key policy issues affecting

industrial development in developing countries, and to identify possible cooperation strategies between NICs.

The other batch of primary data collected focused on the main aspects of the Brazilian experience in developing the informatics industry. The following points were considered when collecting data:

1) companies' reactions to the National Informatics Policy;
2) national support to Science & Technology programmes;
3) linkages between Brazilian and foreign firms;
4) special considerations directly or indirectly related to the PNI including contraband and electronic banking;
5) regional policies targeting science parks, special export zones
6) and other collaborative ventures between Brazilian and non Brazilian firms.

The field work in Brazil was done in two parts. The first one was carried out between December 1987 - April 1988. The second one was carried out between March 1989 - April 1989. The field work included interviews and visits to relevant institutions and firms. The following bodies were visited and their staff interviewed:

Government Bodies

CNPq - Conselho Nacional de Pesquisa
Conselho Nacional de Informática, CONIN
FINEP - Financiadora de Estudos e Projetos
IBGE - Instituto Brasileiro de Geografia e Estatística
IBICT - Instituto Brasileiro de Informação em Ciência a Tecnologia
Ministry of Communications - MINICOM
Ministry of Foreign Affairs - Itamaraty
Ministry of Science and Technology - MCT
National Development Bank - BNDES
Secretaria de Ciência e Tecnologia do Estado de S. Paulo
Special Informatics Secretariat - SEI

These agencies provided relevant information about national science and technology programmes and how it was affected by the national informatics policy; about the policy itself and other sectoral policies regulating other sectors of the electronics complex, and lastly about industrial cooperation programmes.

Universities

USP: Dept Economics
UFRJ - Institute of Industrial Economics
UFRJ/Coppe/ NIT - Nucleo de Inovação Tecnologica
UNICAMP: NPCT - Nucleo de Pesquisa em Ciencia e Tecnologia
IE - Economics Institute

Professional Associations

ABCPAI - Ass. Bras. de Controle de Processos e Automação Industrial
ABICOMP - Ass. Bras. Industria de Computadores e Periféricos
ABINEE - Ass. Bras. da Indústria Electro-eletrônica
ASSESPRO - Ass. Bras. das Empresas de Serviços de Informática
INSISTE - Ass. Bras. de Instrumentação e Sistemas Técnicos e Científicos
SUCESU - Sociedade Usuários de Computadores e Equipamentos Subsidiários

One year prior to going to Brazil, I set up a company survey to obtain data on industrial performance of firms in Brazil. The choice of firms to receive the survey information was based on SEI's list of companies registered as producers of informatics goods and on Abicomp's membership list. A total of 130 firms received an introduction letter from London. Forty nine (49) firms replied the first survey round, or 37.6% of the total. The second round consisted of sending an extensive mail questionnaire covering a wide range of information not readily available from the existing data. A total of 80 questionnaires were sent from Brazil while I was in the country conducting the interviews. A questionnaire schedule is in appendix 4.

Only 17 firm replied to the questionnaires (21%), and interviews were used to compensate for that. The questionnaire was first of all extremely long and complex. As it covered practically the entire spectrum of an industrial operation (research, production, distribution, employment, marketing, management and planning), it could not be answered by a single person. Having to be circulated around the plant, questionnaires were easily lost or left unanswered. Only the larger firms with a division of social communication were able to reply. That, in turn, was very positive, as the seven larger national firms responsible for over 45% of national industrial profits did reply to the questionnaire (Cobra, Digirede, Edisa, Elebra, Labo, IBM, Sid, Unysis). Negatively, I missed capturing the realities of smaller companies trying to keep their heads above water. Company visits and interviews covered some of the gaps left by the survey. I also contacted and visited two banks, 5 distributors and 3 computer repair shops to observe and discuss informatization in the banks, regional sales and contraband.

Firms were selected to be interviewed and visited based on their previous and positive response to the letter and questionnaire, and on their accessibility. I identified 30 firms in the informatics sector (computer and peripherals) located in five geographical areas (South, S. Paulo state, S. Paulo, Rio de Janeiro, Minas Geraes). Of a sample of 30 firms I interviewed 49 people in 16 different companies (three of which are Brazilian based TNCs). Phone interviews were also used when visits could not be

arranged. Three subsidiaries located in the North-East were contacted using this method.

Whenever possible interviews were carried out with managers in four areas: finance, strategic planning, marketing, and production. Despite an ample source of informants and the responses to questionnaires, I faced resistance in obtaining information from interviewees, notably anything that related to illicit practices. Firms located both in S. Paulo and Rio de Janeiro were already quite familiar with researchers studying the subject. Yet many were unwilling to release information that had not already been distributed publicly (e.g., either in the SEI surveys or on the studies produced by professional associations, lobbying groups and so on). Some of firms were used to researchers others were not familiar with or sympathetic to research.

The reasons for this were many. The national industry is heavily regulated by the government. There were concrete barriers to doing business in the sector, such as ways of obtaining foreign technology, importation of components and parts and so on. The divergence between business interests and national targets lead to a surge of illicit business practices (e.g., reverse engineering, contraband, industrial espionage). These difficulties were obvious when trying to use a survey method to complement and cross-check existing information. These gaps are visible in the thesis. Survey, questionnaire and interview material was used throughout the thesis, especially in Chapter four (dealing with science and technology programmes), Chapter five (banking automation and contraband), and in Chapter seven.

To obtain information for the production of the maps used in Chapter six I needed a complete list of all firms operating in the informatics sub-sector and in other sectors of the complex. The first source of information was SEI's computerized 1987/1988 data base of registered firms listing every firm, location, area of operation and year of creation. This list of registered firms is available from the library of SEI, located in the now-extinct Ministry of Science and Technology. The list was updated on a regular basis and included over 400 firms. In addition to this list, and following recommendation of SEI's staff in the Market Study division, I used three other additional lists to cross-check and complement the information. These included:

1. the ABICOMP roster of hardware producers affiliated to the association with a total of 98 firms.
2. the directory of informatics producers in Brazil published by Gazeta Mercantil with 200 firms.
3. A list of the companies that participated in SEI's 1988 annual survey with their year of creation, type of industrial activity, location, and total employment.

The amalgamation of these three sources of data (SEI, ABICOMP and Gazeta Mercantil) resulted in a final list of 368 firms, 168 of which were registered as informatics companies and the remaining 200 engaged in production in other sectors of the electronic complex. The final list was reviewed by SEI to assure that there was no duplication of entries and that all firms included were registered and in business. Appendix 2 gives the alphabetical complete list. In addition to using the data for the production of the four maps, I used it for the production of the bar charts also included in Chapter six.

This information was organized geographically by area and distributed according to the year of creation of firms before being analyzed.

In addition to the above I also researched the development of science parks in Brazil. Primary data on this subject was obtained through interviews with representatives of the parks. Interviews were done during an International Seminar on Science Parks organized by OEA/COPPE/USP between 1-4 December 1987 in Rio de Janeiro. Appendix 3 is the schedule used for interviews. The following parks were being planned or were in operation during the time of the research:

Biotec - Pólo de Biotecnologia do Rio de Janeiro
Certi - Centro Regional de Tecnologia e Informática
Ciatec - Cia de Desenvolvimento do Polo de Alta de Tecnologia de Campinas
Citpar - Centro de Integração de Tecnologia do Pará
Cpqd - Centro de Pesquisa e Desenvolvimento da Telebrás, Campinas
Createm - Centro Regional de Automação Industrial e Telemática, RS
CTI - Centro Tecnológico de Informática da Sei, Campinas
Fundação Parque Tecnológico da Paraíba
Fundação Parque de Alta Tecnologia de Petrópolis, RJ
Fundação Parque de Alta Tecnologia de S. Carlos, SP
NIT/Coppe/UFRJ - Nucleo de Inovação Tecnológica, RJ
NUTEC - Fundação Nucleo de Tecnologia Industrial, Fortaleza, CE
Riotec - Polo de Alta Tecnologia do Rio de Janeiro
SUFRAMA - Superintendencia da Zona Franca de Manaus

These interviews provided information about the parks and where they already had a developed infrastructure, about the role of informatics and other electronics companies on the site. To complement the gaps in the collection of regional data I also

used a survey on Brazilian Science Parks done by USP/COPPE/OEA on the creation of science parks in Latin America.[1]

Secondary Sources

The thesis relied heavily on existing secondary sources including government published works, technical and academic data available. These were as follows:

Government Data

The Ministry of Science and Technology under the supervision of SEI maintains a large data base on the economic life of Brazilian owned companies. SEI publishes an annual survey on the performance of selected sectors of the electronic complex (informatics, telecommunications, microelectronics, instrumentation, automation, software, and informatics services).

The compilation of quantitative data is based on responses to SEI annual surveys. SEI defines its representativeness based on the aggregate sales figures for each sector. For the 1988/89 survey, responses equaled more than 85% of each sector's sales. Most of SEI's figures, some of which are used here, are given in dollars. Values are calculated in terms of the mean of the US$ dollar for a given year. This medium is an index produced by the Getúlio Vargas Foundation in Rio de Janeiro (SEI, 1989:11). Given Brazil's two massive monetary reforms in the past five years, including the creation of a new currency an usually high inflation rate, the usual methods of deflation are not applicable here. Figures produced should reflect as close as possible the reality in a given period

Commercial Data

For the analysis of distribution of computer usage in 20 industrial sectors I used data on the top 600 industrial informatics users published by Gazeta Mercantil. [2] These data were analyzed using Excel Spread Sheet to generate table 6.1 (the distribution of computer installations by 18 sectors of the economy). Finally, I used information collected and published by professional organizations listed above. An extensive bibliography of academic and other technical papers is included below.

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[1] **Implementação de Parques Tecnológicos na América Latina** (1988) Projeto USP/COPPE/OEA. Rio de Janeiro: Coppe/NIT.

[2] ***Dados e Idéias***, no.126, Nov/Dec 1988 "As500 Maiores Empresas Usuárias de Informática."

Appendix 2 List of Firms

Abaco
ABC dados
ABC Telecom
ADD
AIT
Altus
Analitic
Atos
Automatic
Base
BCM
Biodata
Brap
Cad
Cape
CCE Amazonas
CCE Informatica
Cetus
Cirpress
CMC
Codimex
Compart
Compseg
Computel
Contrap
CP
CTL
Daruma
Data Point
Datanav
Dicon
Digigraph
Diginet
Digiponto Amazonas
Digital
Digitus
Distronic
Dynacom
Ecam
Eden
Elebra Computadores
Elebra telecom
Eletrotela
Elogica
Engemac
Engistrel
Equitel
Euro Control
Expansao
Fase
Firmware
GBM
Globus
Gutemberg
Helmac

Abc Bull
Abc Ixtal
Acatec
Addprint
Alfa Digital
Amelco
Anamed
ATS
Automax
Basf
Bergman
BK
Brascom
Calcom
Carton
CCE Computadores
CCM
CFLCL
Cluster
CMW
Columbia
Compasa
Compuleader
Computex
Control
CP Computadores
Cursor
Darumatec
Datacal
Dataregis
Digibyte
Digilab
Digiplay
Digirede
Digitel
Dimep
Drystal
EA- Electronica
Ecil/P&D
Edisa
Elebra Informatica
Eletrocontrol
Elgin
Engecom
Engemauticos
Ensec
Ericson
Evadin
Facit
Fasor
Flexidisc
Geotron
Gradiente
Heliodinamica
Hengesystems

Abc Computadores
ABC Sistemas
Active
Apletronic
Alfatest
Amplus
Ata
Autodata
Bal. Ferrando
Basic
Bese-Rio
Bondwell
Braswey
Cambridge
CBB
CCE
Centelha
Chronos
CMA
Cobra
Com. Dourado
Compo
Computec
Comsip
Control Data
CP Amazonas
Daisy Wheel
Data General
Datamidia
Datateck Diadur
Digicom
Digimat
Digiponto
Digirede Nordeste
Digitron
Dismac
Dots
EBC
Ecodata
EE
Elebra Microelectrnica
Eletrodigi
Elo
Engeletro
Engespaso
Epcom
Escricentre
Ecadin Comp.
Faichild
Ferranti
Fujitsu
Gepeto
Gradiente Computadores
Heller
Hibrid

Hidrologia
HP
Icthus
Imagem
Ind. Romi
Intralab
Italvolt
Itautec
Kintron
Leucotron
Logus
Lz Electronica
Marte
MCS
Medidata
Metal leve
Metrixer
Microcraft
Micronal
Microtec
Mips
Monydata
Mpv
Multidata
NCR
Nortronic
Noxxon
P&D
Pecc
Perifericos
Philco Computadores
PHT
Proceda
Prologo
Psi
Quartzil
Rhede
Ritas
Saga
Schenk
Scritta
Semco
Semp Toshiba Comp.
Sicomig
Sid Telecom
Sinomatic
Sistema
Smar
Sony Computadores
Splice
Standard
Stratus
Swedata
Tandem
Tecnocoop
Telefunken
Tesc
Themag

Honeywell
IBM
Icotron
Impelco
Input
IPS
Itaucam
Jade
Labo
Lince
Luppy Paquay
Magnet
Master
MDA
Mega
Metalma
Microcom
Microlab
Microperifericos
Midia
Moddata
Monytel
Ms
Multidigit
NCT
Novadata
Olivetti
PAA
Pema
Pgm
Philips
Polimax
Procomp
Promptus
Pulse
Racimec
Rifran
Robert Bosch
Sanyo
Schumec
Sector
Semikron
Servus
Sid
Sigma
Sisco
Sistenac
Softec
Sosecal
Splice Amazonas
STD
Sul America
Sysdata
Tauros
Tecnodata
Telematica
Tesis
TME

Houston
Ica
Ikro
Ind. Ramos
Intertecnica
Ipso
Itaucom
Kemitron
Lasertech
Logodata
Lz
Maquis
Maxitec
Mecaf
Menno
Metalzilo
Microdigital
Micromatica
Microsol
Milmar
Moddata Telecom
Moplan
Mtl Universo
Multitel
Nec
Novelprint
Omega
Parks
Percomp
Philco
Philips Comp.
Politronic
Prologica
Protocolo
Qualitron
Remington
Rio Data
Ruf
Schause
Scopus
Sedasa
Semp Toshiba
Sharp
Sid Microelectronica
Sinatron
Sisco Computadores
Sky
Sony
Spectrum
Springer National
STI
Sun Electric
Tabra
TDA
Tecnologia
Telsist
Texas Instrument
Toledo

Transcontinental	Transmicro	Transmitel
Tropical	Troppus	Unicontrol
Unitron	Universal	Unysis
Uptronik	Van Den	Varig
VAT	Verbatim	Victor
Videotek	Vilares	Weg
Wintec	Yok	Zanthus
Zorzi	Zselics.	

Appendix 3 Science Parks Interview Schedule/ Questionnaire

Name _____
City _____
State _____
Park's primary Industrial/R&D activity _____

Number of Firms in the Area/ Park _____
Number of Firms Planning to Join the Scheme _____
Park/Area Capacity _____
Institutional Support/Involvement in the Park _____
Government Agencies _____
Research Institutes, Universities _____
Relationship between park location and proximity to R&D Centres _____
How do universities contribute/participate _____
How does the Government (Nacional, State, Local) contribute/participate _____
Does the Park receive/depend on any incentive _____
Please specify the incentives available, amount, origin and conditions _____
Park's Infrastructure. Please describe the existing facilities _____
Please describe your planned facilities _____
Human resources: Please describe labour resources in your area, Park's labour demands, training facilities, skill levels _____
Number of employees working in the Park today _____
Administration_____Laboratories_____Firms_____Others
Please specify _____
Do you have employment records of previous years_____yes_____no
Please indicate changes in employment over a period of years _____
Has employment expanded/decreased/remained the same Firms Employment: please indicate firm's employment in the following skill categories _____
Administration/Management____Production____Services_____Sales_____R&D____
Markets: The park produces for which market(s) _____
Do firms at the park export_____what_____where_____
Please comment on how you have (not have) achieved your objectives_____
Please list and explain you greatest difficulties _____
Please list any other information you may find relevant _____

Appendix 4 Interview Schedule

The following questionnaire is a translation of the one used during interviews and/or sent to firms. When used at interviews it functioned as a guide to the overall interview. Not all questions were asked at all times given the length and scope of the schedule. Descisions over to what questions to ask were made at my discretion.

PART I - INFORMATIVE

1. GENERAL DATA

1.1 NAME

1.2 ADDRESS

phone: ( )

postal code: State:

1.3 NAME OF INFORMANT (S):

Position

phone ( )

2. Company's History and Organization

2.1 IS THE FIRM?

(mark with an X)

independent	
part of a conglomerate	
subsidiary	
plc company	
limited company	

2.2 MAJOR SHARE HOLDERS

2.3 WAS THE FIRM CONSTITUTED OR PURCHASED BY A GROUP?

2.4 DATE OF CREATION/PURCHASE year

2.5 WHERE ARE THE FOLLOWING DECISIONS MADE?

	Internal Decisions	External Decisions
capital investments		
product development		
production subcontracting		
marketing		
employment policies		
wages		
work organization		

2.6 PLEASE LIST OTHER COMPANIES IN THE GROUP

Name	Market area
1	
2	
3	

3. Social Capital

monetary unit used	1978	1980	1982	1984	1986	1987
CS$						
CZ$						
US$						

4. Market Segment

Indicate with an X your most important market segment

systems

micros		telecommunications	
minis		industrial automation	
super minis		digital instrumentation	
		technical services	
peripheric		others	

5. Economic Performance and Market Shares:

5.1 PROFITS / SALES

a. please inidicate your fiscal year month/yr.

b. indicate conversion indexes used for the given year

c. indicate the monetary unit used Cz$ US$ Cr$ other .....
(circle the option)

activity	1978	1980	1982	1984	1986	1987
sales						
export						
gross profits						
liquid profits						
number of employees						

5.2 SALES AND MARKETING STRATEGIES

Marketing Strategies	1978	1980	1982	1984	1986	1987
Direct sale						
Inidrect sale						
OEM						
Leasing						
rent						

5.3 SECTORAL GROWTH *(please indicate with an x market segments of greatest growth)*

product area	1978	1980	1982	1984	1986	1987
computers						
peripherals						
telecommunications						
semiconductors						
software						
services						
special products						

5.4 IDENTIFY FACTORS THAT MOST AFFECTED/AIDED INDUSTRIAL GROWTH IN THE PERIOD INDICATED ABOVE

6. Investiments

List investments in the following areas
(please specify monetary unit used)

	1978	1980	1982	1984	1986	1987
R&D						
infrastructure construction, installations						
human resources						
marketing						
capital						
new projects						
others						

PART II - PRODUTCS AND PRODUCTION

1. Major Products *List by order of importance your products*

1 _____
2 _____
3 _____
4 _____
5 _____
6 _____

1.1 IDENTIFY % OF PRODUCTION UNDER EACH MARKETING STRATEGY

	Produção					
	1978	1980	1982	1984	1986	1987
Total production						
Commercialization						
Direct Sale						
Indirect Sale						
OEM						
Leasing						
Rent						
Exports						

2. Productive Structure

2.1 IS THE FIRM?

vertically integrated ☐
decentralised ☐

2.2 IF YOU ANSWERED VERTICAL INTEGRATION IDENTIFY, USING THE SCALE PROVIDED THE REASONS WHY THIS FORM OF ORGANIZATION HAS BEEN CHOSEN

RELEVANT = 1-2-3-4-5 = IRELEVANT

'economies of scale' ☐
more capital ☐
risk prevention ☐
greater bargaining power ☐
wider markets ☐
national economic situation favorable to verticalization ☐
industrial policy favourable to verticalization ☐
monopoly powers ☐
more business security ☐

2.3 IF YOUR ANSWER IS DECENTRALIZATION IDENTIFY, USING THE SCALE PROVIDED, THE REASONS FOR YOUR CHOICE.

RELEVANT =1-2-3-4-5= IRRELEVANT

undercapitalization ☐
instability of national economy ☐
industrial policy not favourable to concentration ☐
troble shooting ☐
risk ☐
security ☐
availabilty and realability on suppliers ☐
labour costs ☐
lack of managerial experience ☐
lack of R&D resources ☐
restricted markets ☐

2.4 DOES THE FIRM PLAN (HAVE PLANNED) THE RESTRUCTURING OF ITS ORGANIZATION TO BE MORE COMPETITIVE? yes ☐ no ☐

2.5 WHY? _____

2.6 IDENTIFY AREAS WHICH WILL/HAVE BEEN RESTRUCTURED

production ☐ administration ☐
R&D ☐ marketing ☐
human resources ☐ others ☐

3. Raw materials and suppliers

3.1 NUMBER OF SUPPLIERS active ☐ passive ☐

3.2 LIST YOUR ACTIVE SUPPLIERS

Product	Suppliers
1.....	_____
2.....	_____
3.....	_____
4.....	_____
5.....	_____
6.....	_____

3.3 HOW DOES THE FIRM SELECT A SUPPLIER?
Indicate using the scale provided aspects your firm consider important

RELEVANT=1.2.3.4.5=IRRELEVANT

geographical location ☐
size ☐
previous experince ☐
disponibility ☐
flexibility ☐
competitive market prices ☐
aceptance of the firm's culture ☐
financial capacity ☐
technical assistance ☐
ethical characteristics ☐
professional excellence ☐
others ☐
☐

3.4 WHICH FACTORS MOST AFFECT YOUR RELATIONSHIP WITH THE SUPPLIERS?

RELEVANT=1.2.3.4.5=IRRELEVANT

lack of confiability ☐
scarcity of parts ☐
high prices ☐
inferior quality ☐
non regularity on deliveries ☐
contract ruptures ☐
others ☐
☐

4. Imports:

4.1 LIST YOUR FOREIGN SUPPLIERS

_____
_____
_____
_____

Products	Supplier
1.....	_____
2.....	_____
3.....	_____

4.2 AUTHORIZED IMPORT QUOTAS/ IMPORTATION

Value in US$

Category / Year	1978	1980	1982	1984	1986	1987
Solicited						
Authorised						
Realised						

4.3 IDENTIFY WHAT AFFECTS YOUR IMPORT ACTIVITY

	NEGATIVE	POSITIVE
dificulty to purchase components		
scarcity of components		
high prices		
delivery delays		
resolution 767/1982 of CMN		
lack of financial support		
high interest rates		
high tarrifs		
high taxes		
fiscal incentives of law7232/84		
lack of knowledge of international suppliers		

PART III - MARKETING

1. Markets

1.1 IDENTFY YOUR PRODUCT MARKETS

(please indicate the product(s))

	1	2	3	4
public civil sector				
defence				
rivate sector/capital goods				
consumer goods				
telecommunications				
private banking sector				
public banking sector				
others				

1.2 WHO ARE YOUR COMPETITORS?

Product	Competitor	Prod. similar/brand
1		
2		
3		
4		
5		

2. Production for Exports

2.1 DOES YOUR FIRM EXPORT? yes [ ] no [ ]

If your answer is negative please go to questions 2.6 to 2.10

2.2 % OF YOUR PRODUCTION FOR EXPORTS

2.3 EXPORTABLE PRODUCTS

Products	Sales Volume	Importing countries
1		
2		
3		
4		
5		

2.4 WHO MANAGES YOUR EXPORT ACTIVITIES? [ ] trading [ ]

2.5 DOES YOUR FIRM WANT TO EXPORT?

2.6 WHICH PRODUCTS?

2.7 WHEN?

2.8 IMPORTING COUNTRIES

2.9 PLEASE IDENTIFY, USING THE SCALE PROVIDED, THE PROBLEMS YOU ENCOUNTER TO EXPORT

Relevant= 1-2-3-4-5 = Irrelevant

no knowledge of international markets	
lack of an export policy	
small production	
ample internal market	
non competitive prices	
outdated technology	
TNCs competition	
others	
.....	

3. Commercial Infrastructure

3.1 DOES YOUR COMPANY USE SALES REPRESENTATIVES?

yes [ ] no [ ]

3.2 HOW DOES THE FIRM SELECT A DISTRIBUTOR?

RELEVANT = 1-2-3-4-5 = IRRELEVANT

geographical location	
ample distribution network	
experience in the area	
good technical assistance	
reliability	
finantial stability	
others	

PART IV - TECHNOLOGY

1. R&D INVESTMENTS	1978	1980	1982	1984	1986	1987
($)						
$?.....						

1.1 HOW DOES THE FIRM OBTAIN TECHNOLOGY?

Indentify product and area

	1	2	3	4
licencing				
technology packet				
open technology transference				
copy 'cloning'				
reverse engineering				
transference of personnel and technicians				
others				

2. General Questions

2.1 DOES THE FIRM SELL TECHNOLOGY? yes [ ] no [ ]

2.2 NATIONALLY/INTERNATIONALLY yes [ ] no [ ]

2.3 TO WHOM?

2.4 WHERE TO?

2.5 HOW DO YOU DEFINE THIS TECHNOLOGY

		specify
new industrial techniques		
R&D investments		
capital goods		
Marketing and managerial strategies		
R&D techniques		
Technology imbeded in the final product		
others		

3. Technological change:

3.1 IDENTIFY SECTORS THAT AFFECT OR CURTAIL TECHNOLOGICAL INNOVATION

	affect	curtail
lack of financial resources		
small internal markets		
low participation/exposure to external markets		
restrictive imports policy		
lack of international conatcs		
lack of strategic planning		
lack of fiscal incentives		
no or limited credit		
risk		
no export scale		
bureaucracy of CACEX/SEI		
others		

4. Technology Absorption Programmes

Relevant= 1-2-3-4-5 = Irrelevant

firm that owns technology refuses to transfer it	
no money to buy technology	
market instability	
lack of federal support	
others	

PART V - HUMAN RESOURCES

1. General Information

1.1 TOTAL EMPLOYMENT	1978	1980	1982	1984	1986	1987
wages						
social duties						

employment per division	1978	1980	1982	1984	1986	1987
adminstration						
production						
R&D						
sales						
others						

2. Skill Levels: *most recent data* year

	number	%
university degree		
incomplete university degree		
high school		
other		

3. Professional Profile:

	number	%
managers		
engineers		
technicians		
service		
administrations		
TOTAL		

4. Training:

4.1 DOES THE FIRM TRAIN EMPLOYEES? yes no

4.2 IDETIFY WHO RECEIVES TRAINNING

(mark with an X)

marketing	
development of human resources	
technical services	
administrative support	
R&D	
production	
others	

5.Hiring procedures:

5.1 DOES THE FIRM RECRUIT IN THE REGION/CITY OR OUTSIDE

5.2 DOES THE FIRM SUFFER FROM A LACK OF QUALIFIED PERSONNEL? yes no

Identify the ones that most affect the firm

RELEVANT=1.2.3.4.5=IRRELEVANT

difficulty in hiring	
high labour turnover	
lack of policy for human resources	
high wages for qualified personnel	
high wages outside the region	
high labour turnover of qualified personnel	
lack of qualified personnel in the region/city	

1.Economic Policy

1.1 HOW DID THE CRUZADO PLANS I AND II AFEECT YOUR FIRM?

HOW

	During CRUZADO I	During CRUZADO II
Price freezes		
Increase in the cost of labour		
Increase in demand		
high finantial bills		
Economic stability and possiblity of long term strategic planning		

Which economic problems most affect your firm

Did the market reserve help your firm's business

please comment

you began your acitvities	
interfere with your existing activities	
created problems	
improved	
indiferent	

2. Industrial Policy

2.1 Law 7232/84 INCLUDES A SERIES OF BENEFITS AND SUBSIDIES TO THE NATIONAL INDUSTRY

Has your firm benefits from any of these incentives? Indicate using the chart below.

	yes	no
A.* reduction of import tarrifs for products without national similars		
B.* Reduction of IPI		
C.* reduction of IPI for classified products		
D.*Tariff reduction for investments in R&D ibid for investments in human resources		
C.* Financing Priority given by federal banks for investments and imports		
F.*For SOFTWARE development:		

Indentify which of the incentives listed above have contributed to an improvement of your firm's business

	improved	demaged	indiferent
greater capitalization			
reduction on the price of final goods and services			
greater market competitveness in both internal and external markets			
import substitution			
greater R&D capacity			
industrial verticalization mergers and aquisitions			
increase of exports			
software development			
greater technological capacity for the production of microelectronics components			
more qualified employees			

4. Information/cooperation/ Consultancy

4.1 IS THE FIRM A MEMBER OF ANY OF THE FOLLOWING ORGAN *indicate*

ABCPAI		ABINEE		INSISTE	
ABCIN		ANFORSAI		SUSESU	
ABICOMP		ASSESPRO		APPD	

OUTRAS _____

4.2 IS YOUR FIRM AWARE OF ANY OF THE TECHNICAL COOPERATION PROGRAMMES?
indicate familiar (f), not known (n)

national		International	
ADTEN/FINEP		CYTED (Espanha x America Latina (LA)	
AUSC/FINEP		PLANETA/UN-IBI (Coop. America latina)	
ACN/FINEP		CALAI (Conf. Inform. AL)	
FNDCT/FINEP - MCT		ESPRIT (Coop. tecn. Comunidade Europeia)	
ftware Support Programme		ALVEY (Coop. empresa/estado UK)	
- Manufacturing Automation		"STAR WARS" (P&D. tecn EUA)	
others		"5a. geração" (P&D Japão)	
		ARGENTINAXBRASIL	
		PORTUGALXBRAZIL	

4.3 DOES THE FIRM WISH TO TAKE PART IN ANY OF THESE PROGRAMMES?

_____

_____

4.4 IS YOUR FIRM PAR OF ANY OF THE FOLLOWING SCHEMES?

CIATEC, Campinas		RIOTEC, RJ	
CITPAR, Paraná		others	
CREATEM, RS			

If you give a positive answer

4.5 WHICH ARE THE BENEFITS? _____

_____

4.6 WOULD YOU USE OF THE CONSULTANCY SERVICES OFFERED BY THE AGENCIES LISTED BELOW?
please indicate yes (y) or no (n)

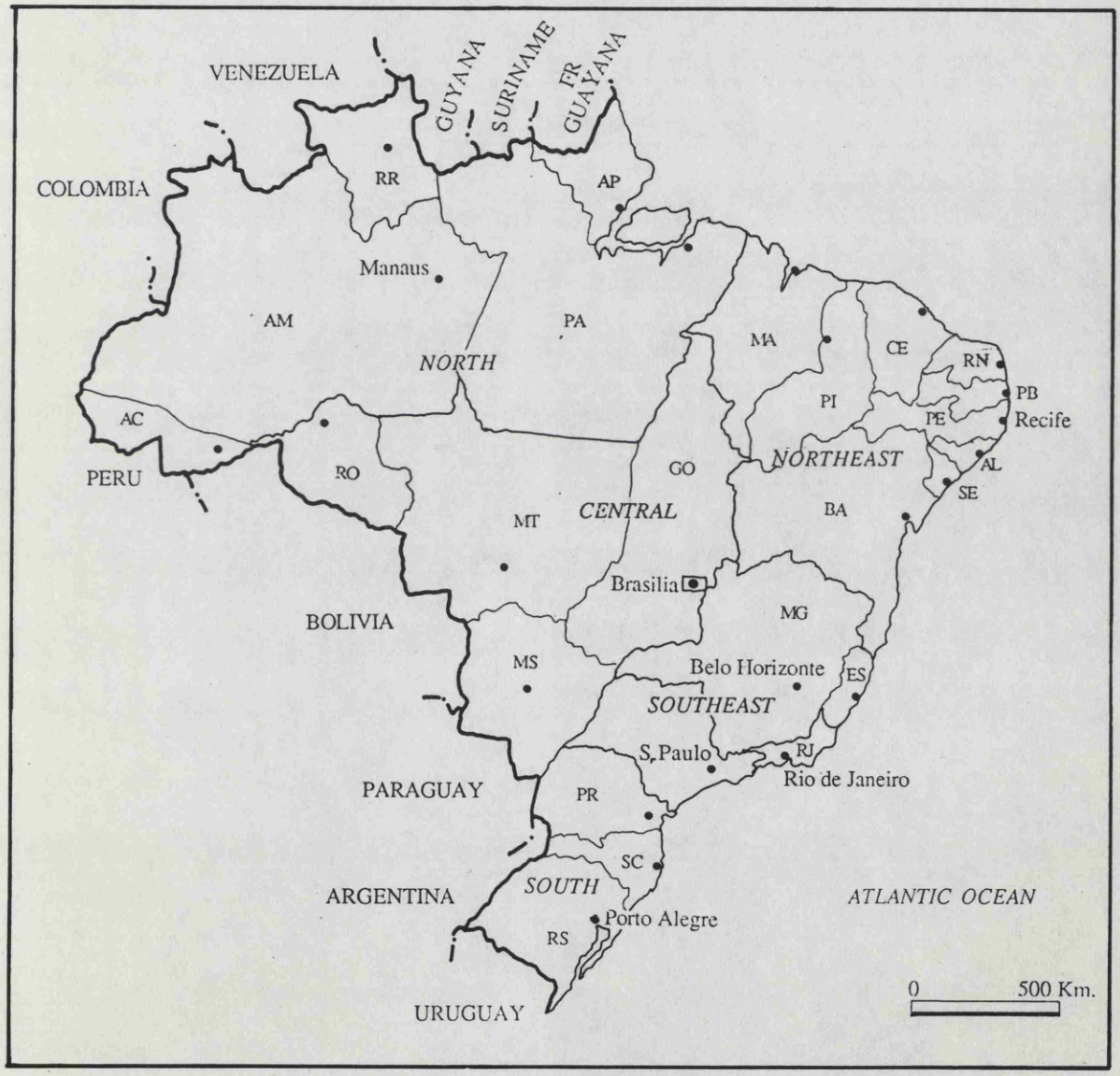
CNPq		Brasilia
CPO (Centro Info em P&D)		Brasilia
CPCT (Centro Estudos Polit. Cientif.)		Brasilia
CTI (Centro Tecn. Informat. SEI)		Campinas
IBICT (Inst. info. cienc. & tecn.)		Brasilia
PROIN (prog. formac. RH informt.)		Campinas/Unicamp
TIPS (Sist. Piloto Info. Tecn.)		UN/Brasilia

outros .....

Appendix 5 Reference Maps

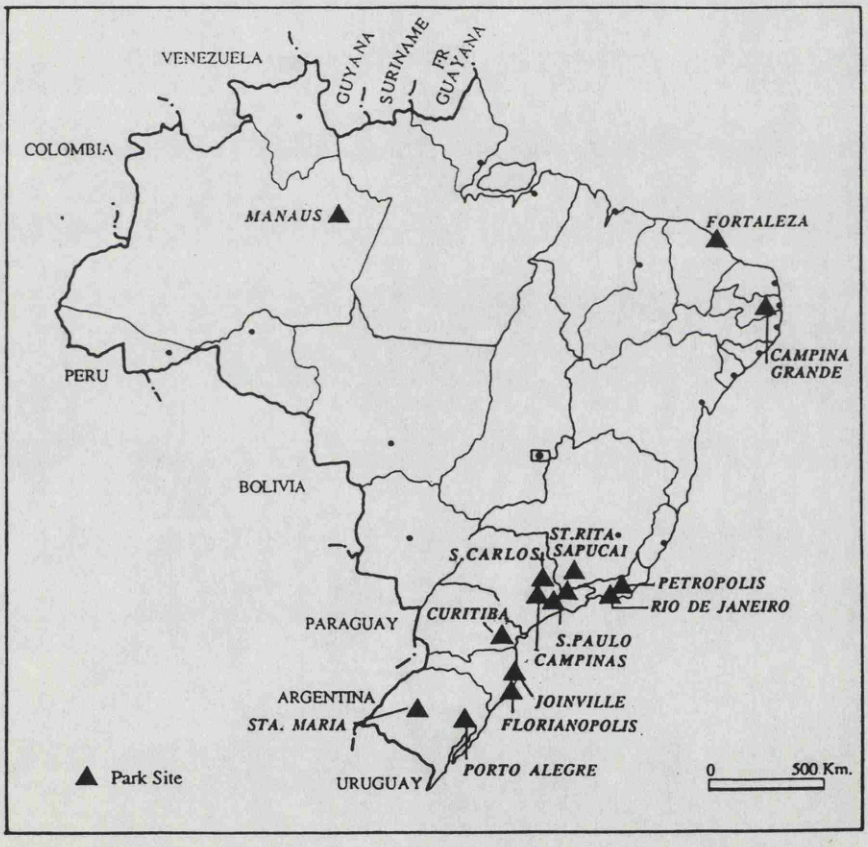
MAP 5

Locational Map of Brazil



MAP 6

Locational Map of Science Parks in Brazil



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